三. Netty 进阶

1. 粘包与半包

1.1 粘包现象

服务端代码

```java
public class HelloWorldServer {
    static final Logger log = LoggerFactory.getLogger(HelloWorldServer.class);
    void start() {
        NioEventLoopGroup boss = new NioEventLoopGroup(1);
        NioEventLoopGroup worker = new NioEventLoopGroup();
        try {
            ServerBootstrap serverBootstrap = new ServerBootstrap();
            serverBootstrap.channel(NioServerSocketChannel.class);
            serverBootstrap.group(boss, worker);
            serverBootstrap.childHandler(new ChannelInitializer<SocketChannel>()
{
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    ch.pipeline().addLast(new LoggingHandler(LogLevel.DEBUG));
                    ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                        @Override
                        public void channelActive(ChannelHandlerContext ctx)
throws Exception {
                            log.debug("connected {}", ctx.channel());
                            super.channelActive(ctx);
                        }

                        @Override
                        public void channelInactive(ChannelHandlerContext ctx)
throws Exception {
                            log.debug("disconnect {}", ctx.channel());
                            super.channelInactive(ctx);
                        }
                    });
                }
            });
            ChannelFuture channelFuture = serverBootstrap.bind(8080);
            log.debug("{} binding...", channelFuture.channel());
            channelFuture.sync();
            log.debug("{} bound...", channelFuture.channel());
            channelFuture.channel().closeFuture().sync();
        } catch (InterruptedException e) {
            log.error("server error", e);
        } finally {
            boss.shutdownGracefully();
            worker.shutdownGracefully();
            log.debug("stoped");
        }
    }
    public static void main(String[] args) {
        new HelloWorldServer().start();
    }
}
```

客户端代码希望发送 10 个消息，每个消息是 16 字节

```
public class HelloWorldClient {
    static final Logger log = LoggerFactory.getLogger(HelloWorldClient.class);
    public static void main(String[] args) {
        NioEventLoopGroup worker = new NioEventLoopGroup();
        try {
            Bootstrap bootstrap = new Bootstrap();
            bootstrap.channel(NioSocketChannel.class);
            bootstrap.group(worker);
            bootstrap.handler(new ChannelInitializer<SocketChannel>() {
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    log.debug("connetted...");
                    ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                        @Override
                        public void channelActive(ChannelHandlerContext ctx)
throws Exception {
                            log.debug("sending...");
                            Random r = new Random();
                            char c = 'a';
                            for (int i = 0; i < 10; i++) {
                                ByteBuf buffer = ctx.alloc().buffer();
                                buffer.writeBytes(new byte[]{0, 1, 2, 3, 4, 5,
6, 7, 8, 9, 10, 11, 12, 13, 14, 15});
                                ctx.writeAndFlush(buffer);
                            }
                        }
                    });
                }
            });
            ChannelFuture channelFuture = bootstrap.connect("127.0.0.1",
8080).sync();
            channelFuture.channel().closeFuture().sync();

        } catch (InterruptedException e) {
            log.error("client error", e);
        } finally {
            worker.shutdownGracefully();
        }
    }
}
```

服务器端的某次输出，可以看到一次就接收了 160 个字节，而非分 10 次接收

```
08:24:46 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0x81e0fda5] binding...
08:24:46 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0x81e0fda5,
L:/0:0:0:0:0:0:0:0:8080] bound...
08:24:55 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x94132411, L:/127.0.0.1:8080 - R:/127.0.0.1:58177] REGISTERED
```

```
08:24:55 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x94132411, L:/127.0.0.1:8080 - R:/127.0.0.1:58177] ACTIVE
08:24:55 [DEBUG] [nioEventLoopGroup-3-1] c.i.n.HelloWorldServer - connected [id:
0x94132411, L:/127.0.0.1:8080 - R:/127.0.0.1:58177]
08:24:55 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x94132411, L:/127.0.0.1:8080 - R:/127.0.0.1:58177] READ: 160B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000010| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000020| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000030| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000040| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000050| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000060| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000070| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000080| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000090| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
+--------+-------------------------------------------------+----------------+
08:24:55 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x94132411, L:/127.0.0.1:8080 - R:/127.0.0.1:58177] READ COMPLETE
```

1.2 半包现象

客户端代码希望发送 1 个消息，这个消息是 160 字节，代码改为

```java
ByteBuf buffer = ctx.alloc().buffer();
for (int i = 0; i < 10; i++) {
    buffer.writeBytes(new byte[]{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,
14, 15});
}
ctx.writeAndFlush(buffer);
```

为现象明显，服务端修改一下接收缓冲区，其它代码不变

```java
serverBootstrap.option(ChannelOption.SO_RCVBUF, 10);
```

服务器端的某次输出，可以看到接收的消息被分为两节，第一次 20 字节，第二次 140 字节

```
08:43:49 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0x4d6c6a84] binding...
08:43:49 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0x4d6c6a84,
L:/0:0:0:0:0:0:0:0:8080] bound...
08:44:23 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x1719abf7, L:/127.0.0.1:8080 - R:/127.0.0.1:59221] REGISTERED
08:44:23 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x1719abf7, L:/127.0.0.1:8080 - R:/127.0.0.1:59221] ACTIVE
08:44:23 [DEBUG] [nioEventLoopGroup-3-1] c.i.n.HelloWorldServer - connected [id:
0x1719abf7, L:/127.0.0.1:8080 - R:/127.0.0.1:59221]
08:44:24 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x1719abf7, L:/127.0.0.1:8080 - R:/127.0.0.1:59221] READ: 20B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f |................|
|00000010| 00 01 02 03                                     |....            |
+--------+-------------------------------------------------+----------------+
08:44:24 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x1719abf7, L:/127.0.0.1:8080 - R:/127.0.0.1:59221] READ COMPLETE
08:44:24 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x1719abf7, L:/127.0.0.1:8080 - R:/127.0.0.1:59221] READ: 140B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000010| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000020| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000030| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000040| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000050| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000060| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000070| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 00 01 02 03 |................|
|00000080| 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f             |............    |
+--------+-------------------------------------------------+----------------+
08:44:24 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x1719abf7, L:/127.0.0.1:8080 - R:/127.0.0.1:59221] READ COMPLETE
```

> **注意**
>
> serverBootstrap.option(ChannelOption.SO_RCVBUF, 10) 影响的底层接收缓冲区（即滑动窗口）大小，仅决定了 netty 读取的最小单位，netty 实际每次读取的一般是它的整数倍

1.3 现象分析

粘包

- 现象，发送 abc def，接收 abcdef
- 原因
  - 应用层：接收方 ByteBuf 设置太大（Netty 默认 1024）
  - 滑动窗口：假设发送方 256 bytes 表示一个完整报文，但由于接收方处理不及时且窗口大小足够大，这 256 bytes 字节就会缓冲在接收方的滑动窗口中，当滑动窗口中缓冲了多个报文就会粘包
  - Nagle 算法：会造成粘包

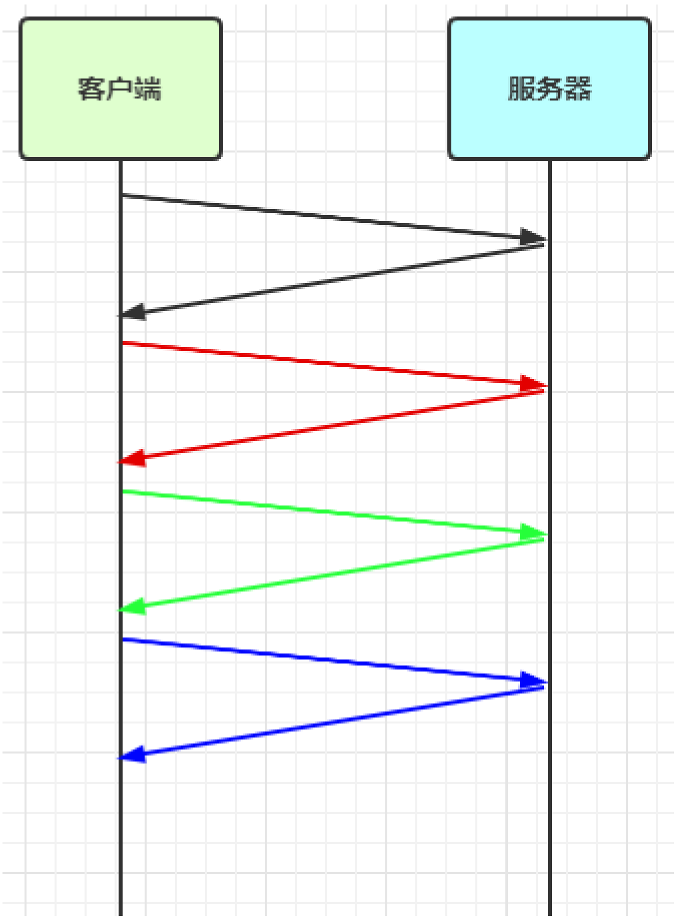
半包

- 现象，发送 abcdef，接收 abc def
- 原因
  - 应用层：接收方 ByteBuf 小于实际发送数据量
  - 滑动窗口：假设接收方的窗口只剩了 128 bytes，发送方的报文大小是 256 bytes，这时放不下了，只能先发送前 128 bytes，等待 ack 后才能发送剩余部分，这就造成了半包
  - MSS 限制：当发送的数据超过 MSS 限制后，会将数据切分发送，就会造成半包

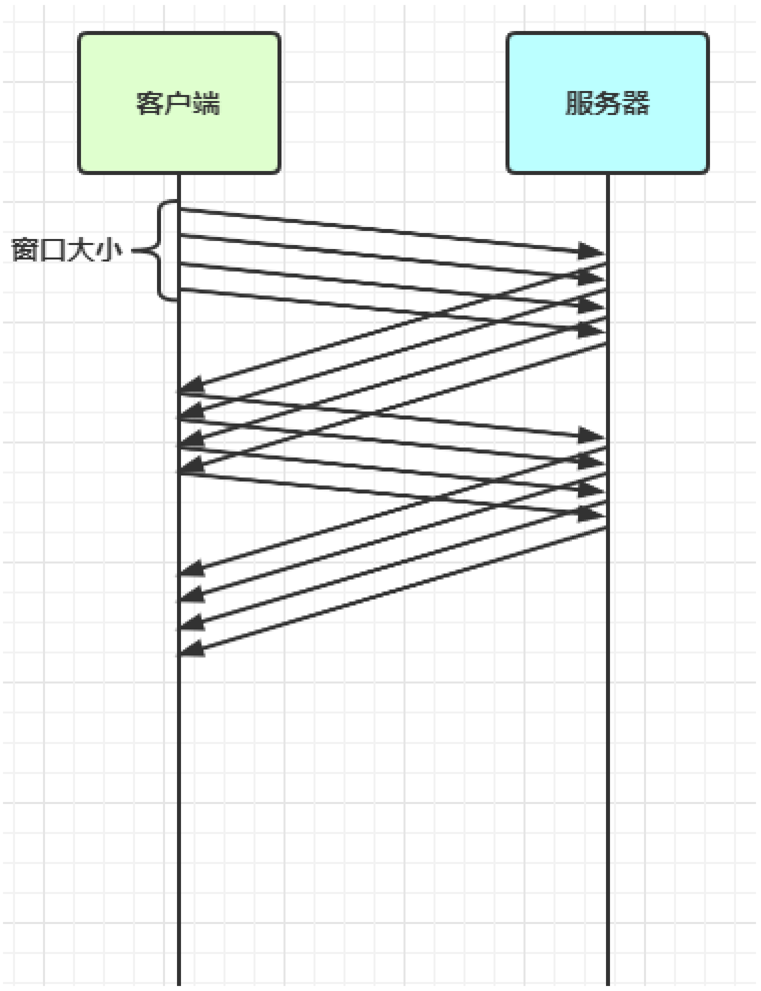
本质是因为 TCP 是流式协议，消息无边界

滑动窗口

- TCP 以一个段（segment）为单位，每发送一个段就需要进行一次确认应答（ack）处理，但如果这么做，缺点是包的往返时间越长性能就越差



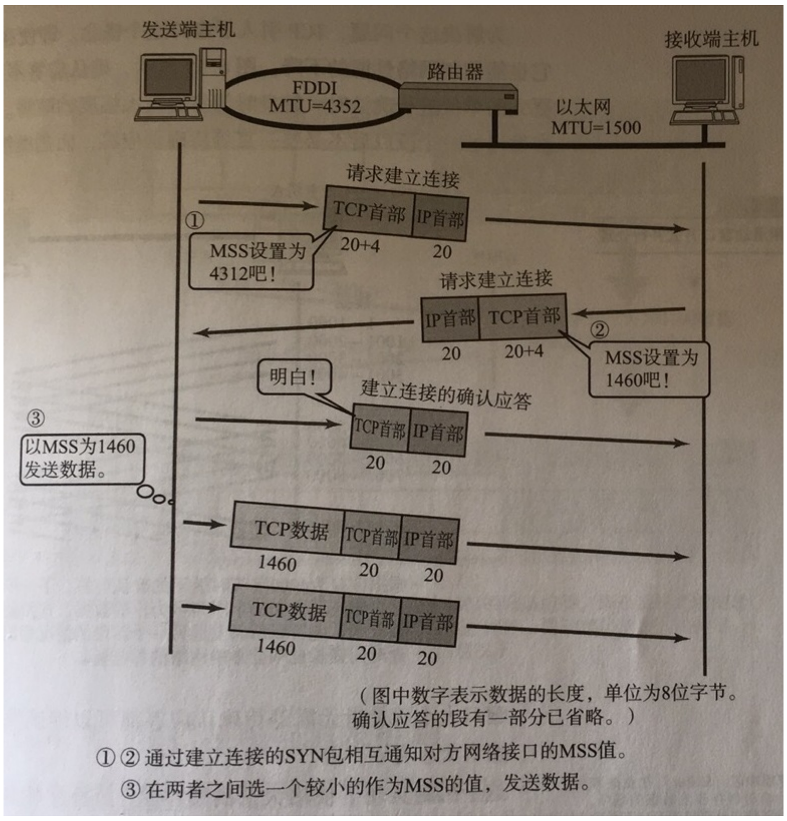
- 为了解决此问题，引入了窗口概念，窗口大小即决定了无需等待应答而可以继续发送的数据最大值



- 窗口实际就起到一个缓冲区的作用，同时也能起到流量控制的作用
    - 图中深色的部分即要发送的数据，高亮的部分即窗口
    - 窗口内的数据才允许被发送，当应答未到达前，窗口必须停止滑动
    - 如果 1001~2000 这个段的数据 ack 回来了，窗口就可以向前滑动
    - 接收方也会维护一个窗口，只有落在窗口内的数据才能允许接收

MSS 限制

- 链路层对一次能够发送的最大数据有限制，这个限制称之为 MTU（maximum transmission unit），不同的链路设备的 MTU 值也有所不同，例如
- 以太网的 MTU 是 1500
- FDDI（光纤分布式数据接口）的 MTU 是 4352
- 本地回环地址的 MTU 是 65535 - 本地测试不走网卡
- MSS 是最大段长度（maximum segment size），它是 MTU 刨去 tcp 头和 ip 头后剩余能够作为数据传输的字节数
- ipv4 tcp 头占用 20 bytes，ip 头占用 20 bytes，因此以太网 MSS 的值为 1500 - 40 = 1460
- TCP 在传递大量数据时，会按照 MSS 大小将数据进行分割发送
- MSS 的值在三次握手时通知对方自己 MSS 的值，然后在两者之间选择一个小值作为 MSS



（图中数字表示数据的长度，单位为8位字节。确认应答的段有一部分已省略。）

①② 通过建立连接的SYN包相互通知对方网络接口的MSS值。

③ 在两者之间选一个较小的作为MSS的值，发送数据。

> Nagle 算法
>
> * 即使发送一个字节，也需要加入 tcp 头和 ip 头，也就是总字节数会使用 41 bytes，非常不经济。因此为了提高网络利用率，tcp 希望尽可能发送足够大的数据，这就是 Nagle 算法产生的缘由
> * 该算法是指发送端即使还有应该发送的数据，但如果这部分数据很少的话，则进行延迟发送
>   * 如果 SO_SNDBUF 的数据达到 MSS，则需要发送
>   * 如果 SO_SNDBUF 中含有 FIN（表示需要连接关闭）这时将剩余数据发送，再关闭
>   * 如果 TCP_NODELAY = true，则需要发送
>   * 已发送的数据都收到 ack 时，则需要发送
>   * 上述条件不满足，但发生超时（一般为 200ms）则需要发送
>   * 除上述情况，延迟发送

1.4 解决方案

1. 短链接，发一个包建立一次连接，这样连接建立到连接断开之间就是消息的边界，缺点效率太低
2. 每一条消息采用固定长度，缺点浪费空间
3. 每一条消息采用分隔符，例如 \n，缺点需要转义
4. 每一条消息分为 head 和 body，head 中包含 body 的长度

方法1，短链接

以解决粘包为例

```java
public class HelloWorldClient {
    static final Logger log = LoggerFactory.getLogger(HelloWorldClient.class);
    public static void main(String[] args) {
        // 分 10 次发送
        for (int i = 0; i < 10; i++) {
            send();
        }
    }

    private static void send() {
        NioEventLoopGroup worker = new NioEventLoopGroup();
        try {
            Bootstrap bootstrap = new Bootstrap();
            bootstrap.channel(NioSocketChannel.class);
            bootstrap.group(worker);
            bootstrap.handler(new ChannelInitializer<SocketChannel>() {
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    log.debug("conneted...");
                    ch.pipeline().addLast(new LoggingHandler(LogLevel.DEBUG));
                    ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                        @Override
                        public void channelActive(ChannelHandlerContext ctx)
throws Exception {
                            log.debug("sending...");
                            ByteBuf buffer = ctx.alloc().buffer();
                            buffer.writeBytes(new byte[]{0, 1, 2, 3, 4, 5, 6, 7,
8, 9, 10, 11, 12, 13, 14, 15});
                            ctx.writeAndFlush(buffer);
                            // 发完即关
                            ctx.close();
                        }
                    });
                }
            });
            ChannelFuture channelFuture = bootstrap.connect("localhost",
8080).sync();
            channelFuture.channel().closeFuture().sync();

        } catch (InterruptedException e) {
            log.error("client error", e);
        } finally {
            worker.shutdownGracefully();
        }
    }
}
```

输出，略

> 半包用这种办法还是不好解决，因为接收方的缓冲区大小是有限的

方法2，固定长度

让所有数据包长度固定（假设长度为 8 字节），服务器端加入

```
ch.pipeline().addLast(new FixedLengthFrameDecoder(8));
```

客户端测试代码，注意，采用这种方法后，客户端什么时候 flush 都可以

```
public class HelloWorldClient {
    static final Logger log = LoggerFactory.getLogger(HelloWorldClient.class);

    public static void main(String[] args) {
        NioEventLoopGroup worker = new NioEventLoopGroup();
        try {
            Bootstrap bootstrap = new Bootstrap();
            bootstrap.channel(NioSocketChannel.class);
            bootstrap.group(worker);
            bootstrap.handler(new ChannelInitializer<SocketChannel>() {
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    log.debug("connetted...");
                    ch.pipeline().addLast(new LoggingHandler(LogLevel.DEBUG));
                    ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                        @Override
                        public void channelActive(ChannelHandlerContext ctx)
throws Exception {
                            log.debug("sending...");
                            // 发送内容随机的数据包
                            Random r = new Random();
                            char c = 'a';
                            ByteBuf buffer = ctx.alloc().buffer();
                            for (int i = 0; i < 10; i++) {
                                byte[] bytes = new byte[8];
                                for (int j = 0; j < r.nextInt(8); j++) {
                                    bytes[j] = (byte) c;
                                }
                                c++;
                                buffer.writeBytes(bytes);
                            }
                            ctx.writeAndFlush(buffer);
                        }
                    });
                }
            });
            ChannelFuture channelFuture = bootstrap.connect("192.168.0.103",
9090).sync();
            channelFuture.channel().closeFuture().sync();

        } catch (InterruptedException e) {
            log.error("client error", e);
        } finally {
            worker.shutdownGracefully();
        }
    }
}
```

客户端输出

```
12:07:00 [DEBUG] [nioEventLoopGroup-2-1] c.i.n.HelloWorldClient - connetted...
12:07:00 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x3c2ef3c2] REGISTERED
12:07:00 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x3c2ef3c2] CONNECT: /192.168.0.103:9090
```

```
12:07:00 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x3c2ef3c2, L:/192.168.0.103:53155 - R:/192.168.0.103:9090] ACTIVE
12:07:00 [DEBUG] [nioEventLoopGroup-2-1] c.i.n.HelloWorldClient - sending...
12:07:00 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x3c2ef3c2, L:/192.168.0.103:53155 - R:/192.168.0.103:9090] WRITE: 80B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 61 61 61 61 00 00 00 00 62 00 00 00 00 00 00 00 |aaaa....b.......|
|00000010| 63 63 00 00 00 00 00 00 64 00 00 00 00 00 00 00 |cc......d.......|
|00000020| 00 00 00 00 00 00 00 00 66 66 66 66 00 00 00 00 |........ffff....|
|00000030| 67 67 67 00 00 00 00 00 68 00 00 00 00 00 00 00 |ggg.....h.......|
|00000040| 69 69 69 69 69 00 00 00 6a 6a 6a 6a 00 00 00 00 |iiiii...jjjj....|
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x3c2ef3c2, L:/192.168.0.103:53155 - R:/192.168.0.103:9090] FLUSH
```

服务端输出

```
12:06:51 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0xe3d9713f] binding...
12:06:51 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0xe3d9713f,
L:/192.168.0.103:9090] bound...
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] REGISTERED
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] ACTIVE
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] c.i.n.HelloWorldServer - connected [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155]
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 61 61 61 61 00 00 00 00                         |aaaa....        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 62 00 00 00 00 00 00 00                         |b.......        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 63 63 00 00 00 00 00 00                         |cc......        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 64 00 00 00 00 00 00 00                         |d.......        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 00 00 00 00 00 00 00 00                         |........        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 66 66 66 66 00 00 00 00                         |ffff....        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 67 67 67 00 00 00 00 00                         |ggg.....        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 68 00 00 00 00 00 00 00                         |h.......        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 69 69 69 69 69 00 00 00                         |iiiii...        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 6a 6a 6a 6a 00 00 00 00                         |jjjj....        |
+--------+-------------------------------------------------+----------------+
12:07:00 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0xd739f137, L:/192.168.0.103:9090 - R:/192.168.0.103:53155] READ COMPLETE
```

缺点是，数据包的大小不好把握

- 长度定的太大，浪费
- 长度定的太小，对某些数据包又显得不够

方法3，固定分隔符

服务端加入，默认以 \n 或 \r\n 作为分隔符，如果超出指定长度仍未出现分隔符，则抛出异常

```
ch.pipeline().addLast(new LineBasedFrameDecoder(1024));
```

客户端在每条消息之后，加入 \n 分隔符

```java
public class HelloWorldClient {
    static final Logger log = LoggerFactory.getLogger(HelloWorldClient.class);

    public static void main(String[] args) {
        NioEventLoopGroup worker = new NioEventLoopGroup();
        try {
            Bootstrap bootstrap = new Bootstrap();
            bootstrap.channel(NioSocketChannel.class);
            bootstrap.group(worker);
            bootstrap.handler(new ChannelInitializer<SocketChannel>() {
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    log.debug("connetted...");
                    ch.pipeline().addLast(new LoggingHandler(LogLevel.DEBUG));
                    ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                        @Override
                        public void channelActive(ChannelHandlerContext ctx)
throws Exception {
                            log.debug("sending...");
                            Random r = new Random();
                            char c = 'a';
                            ByteBuf buffer = ctx.alloc().buffer();
                            for (int i = 0; i < 10; i++) {
                                for (int j = 1; j <= r.nextInt(16)+1; j++) {
                                    buffer.writeByte((byte) c);
                                }
                                buffer.writeByte(10);
                                c++;
                            }
                            ctx.writeAndFlush(buffer);
                        }
                    });
                }
            });
            ChannelFuture channelFuture = bootstrap.connect("192.168.0.103",
9090).sync();
            channelFuture.channel().closeFuture().sync();

        } catch (InterruptedException e) {
            log.error("client error", e);
        } finally {
            worker.shutdownGracefully();
        }
    }
}
```

客户端输出

```
14:08:18 [DEBUG] [nioEventLoopGroup-2-1] c.i.n.HelloWorldClient - connetted...
14:08:18 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x1282d755] REGISTERED
14:08:18 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x1282d755] CONNECT: /192.168.0.103:9090
14:08:18 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x1282d755, L:/192.168.0.103:63641 - R:/192.168.0.103:9090] ACTIVE
```

```
14:08:18 [DEBUG] [nioEventLoopGroup-2-1] c.i.n.HelloWorldClient - sending...
14:08:18 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x1282d755, L:/192.168.0.103:63641 - R:/192.168.0.103:9090] WRITE: 60B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 61 0a 62 62 62 0a 63 63 63 0a 64 64 0a 65 65 65 |a.bbb.ccc.dd.eee|
|00000010| 65 65 65 65 65 65 65 0a 66 66 0a 67 67 67 67 67 |eeeeeee.ff.ggggg|
|00000020| 67 67 0a 68 68 68 68 0a 69 69 69 69 69 69 69 0a |gg.hhhh.iiiiiii.|
|00000030| 6a 6a 6a 6a 6a 6a 6a 6a 6a 6a 6a 0a             |jjjjjjjjjjj.    |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0x1282d755, L:/192.168.0.103:63641 - R:/192.168.0.103:9090] FLUSH
```

服务端输出

```
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] c.i.n.HelloWorldServer - connected [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641]
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 1B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 61                                              |a               |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 3B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 62 62 62                                        |bbb             |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 3B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 63 63 63                                        |ccc             |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 2B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 64 64                                           |dd              |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 10B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 65 65 65 65 65 65 65 65 65 65                   |eeeeeeeeee      |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 2B
```

```
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 66 66                                           |ff              |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 7B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 67 67 67 67 67 67 67                            |ggggggg         |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 4B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 68 68 68 68                                     |hhhh            |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 7B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 69 69 69 69 69 69 69                            |iiiiiii         |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ: 11B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 6a 6a 6a 6a 6a 6a 6a 6a 6a 6a 6a                |jjjjjjjjjjj     |
+--------+-------------------------------------------------+----------------+
14:08:18 [DEBUG] [nioEventLoopGroup-3-5] i.n.h.l.LoggingHandler - [id:
0xa4b3be43, L:/192.168.0.103:9090 - R:/192.168.0.103:63641] READ COMPLETE
```

缺点，处理字符数据比较合适，但如果内容本身包含了分隔符（字节数据常常会有此情况），那么就会解析错误

方法4，预设长度

在发送消息前，先约定用定长字节表示接下来数据的长度

```java
// 最大长度，长度偏移，长度占用字节，长度调整，剥离字节数
ch.pipeline().addLast(new LengthFieldBasedFrameDecoder(1024, 0, 1, 0, 1));
```

客户端代码

```java
public class HelloWorldClient {
    static final Logger log = LoggerFactory.getLogger(HelloWorldClient.class);

    public static void main(String[] args) {
        NioEventLoopGroup worker = new NioEventLoopGroup();
        try {
            Bootstrap bootstrap = new Bootstrap();
            bootstrap.channel(NioSocketChannel.class);
            bootstrap.group(worker);
            bootstrap.handler(new ChannelInitializer<SocketChannel>() {
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    log.debug("connetted...");
                    ch.pipeline().addLast(new LoggingHandler(LogLevel.DEBUG));
                    ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                        @Override
                        public void channelActive(ChannelHandlerContext ctx)
throws Exception {
                            log.debug("sending...");
                            Random r = new Random();
                            char c = 'a';
                            ByteBuf buffer = ctx.alloc().buffer();
                            for (int i = 0; i < 10; i++) {
                                byte length = (byte) (r.nextInt(16) + 1);
                                // 先写入长度
                                buffer.writeByte(length);
                                // 再
                                for (int j = 1; j <= length; j++) {
                                    buffer.writeByte((byte) c);
                                }
                                c++;
                            }
                            ctx.writeAndFlush(buffer);
                        }
                    });
                }
            });
            ChannelFuture channelFuture = bootstrap.connect("192.168.0.103",
9090).sync();
            channelFuture.channel().closeFuture().sync();

        } catch (InterruptedException e) {
            log.error("client error", e);
        } finally {
            worker.shutdownGracefully();
        }
    }
}
```

客户端输出

```
14:37:10 [DEBUG] [nioEventLoopGroup-2-1] c.i.n.HelloWorldClient - connetted...
14:37:10 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0xf0f347b8] REGISTERED
14:37:10 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0xf0f347b8] CONNECT: /192.168.0.103:9090
14:37:10 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0xf0f347b8, L:/192.168.0.103:49979 - R:/192.168.0.103:9090] ACTIVE
14:37:10 [DEBUG] [nioEventLoopGroup-2-1] c.i.n.HelloWorldClient - sending...
14:37:10 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0xf0f347b8, L:/192.168.0.103:49979 - R:/192.168.0.103:9090] WRITE: 97B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 09 61 61 61 61 61 61 61 61 61 09 62 62 62 62 62 |.aaaaaaaaa.bbbbb|
|00000010| 62 62 62 62 06 63 63 63 63 63 63 08 64 64 64 64 |bbbb.cccccc.dddd|
|00000020| 64 64 64 64 0f 65 65 65 65 65 65 65 65 65 65 65 |dddd.eeeeeeeeeee|
|00000030| 65 65 65 65 0d 66 66 66 66 66 66 66 66 66 66 66 |eeee.fffffffffff|
|00000040| 66 66 02 67 67 02 68 68 0e 69 69 69 69 69 69 69 |ff.gg.hh.iiiiiii|
|00000050| 69 69 69 69 69 69 69 09 6a 6a 6a 6a 6a 6a 6a 6a |iiiiiii.jjjjjjjj|
|00000060| 6a                                              |j               |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-2-1] i.n.h.l.LoggingHandler - [id:
0xf0f347b8, L:/192.168.0.103:49979 - R:/192.168.0.103:9090] FLUSH
```

服务端输出

```
14:36:50 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0xdff439d3] binding...
14:36:51 [DEBUG] [main] c.i.n.HelloWorldServer - [id: 0xdff439d3,
L:/192.168.0.103:9090] bound...
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] REGISTERED
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] ACTIVE
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] c.i.n.HelloWorldServer - connected [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979]
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 9B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 61 61 61 61 61 61 61 61 61                      |aaaaaaaaa       |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 9B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 62 62 62 62 62 62 62 62 62                      |bbbbbbbbb       |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 6B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 63 63 63 63 63 63                               |cccccc          |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 8B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 64 64 64 64 64 64 64 64                         |dddddddd        |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 15B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 65 65 65 65 65 65 65 65 65 65 65 65 65 65 65    |eeeeeeeeeeeeeee |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 13B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 66 66 66 66 66 66 66 66 66 66 66 66 66          |fffffffffffff   |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 2B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 67 67                                           |gg              |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 2B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 68 68                                           |hh              |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 14B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 69 69 69 69 69 69 69 69 69 69 69 69 69 69       |iiiiiiiiiiiiii  |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ: 9B
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 6a 6a 6a 6a 6a 6a 6a 6a 6a                      |jjjjjjjjj       |
+--------+-------------------------------------------------+----------------+
14:37:10 [DEBUG] [nioEventLoopGroup-3-1] i.n.h.l.LoggingHandler - [id:
0x744f2b47, L:/192.168.0.103:9090 - R:/192.168.0.103:49979] READ COMPLETE
```

2. 协议设计与解析

2.1 为什么需要协议?

TCP/IP 中消息传输基于流的方式，没有边界。

协议的目的就是划定消息的边界，制定通信双方要共同遵守的通信规则

例如：在网络上传输

```
下雨天留客天留我不留
```

是中文一句著名的无标点符号句子，在没有标点符号情况下，这句话有数种拆解方式，而意思却是完全不同，所以常被用作讲述标点符号的重要性

一种解读

```
下雨天留客，天留，我不留
```

另一种解读

```
下雨天，留客天，留我不？留
```

如何设计协议呢？其实就是给网络传输的信息加上"标点符号"。但通过分隔符来断句不是很好，因为分隔符本身如果用于传输，那么必须加以区分。因此，下面一种协议较为常用

```
定长字节表示内容长度 + 实际内容
```

例如，假设一个中文字符长度为 3，按照上述协议的规则，发送信息方式如下，就不会被接收方弄错意思了

```
0f下雨天留客06天留09我不留
```

> 小故事
>
> 很久很久以前，一位私塾先生到一家任教。双方签订了一纸协议："无鸡鸭亦可无鱼肉亦可白菜豆腐不可少不得束修金"。此后，私塾先生虽然认真教课，但主人家则总是给私塾先生以白菜豆腐为菜，丝毫未见鸡鸭鱼肉的款待。私塾先生先是很不解，可是后来也就想通了：主人把鸡鸭鱼肉的钱都会换为束修金的，也罢。至此双方相安无事。
>
> 年关将至，一个学年段亦告结束。私塾先生临行时，也不见主人家为他交付束修金，遂与主家理论。然主家亦振振有词："有协议为证——无鸡鸭亦可，无鱼肉亦可，白菜豆腐不可少，不得束修金。这白纸黑字明摆着的，你有什么要说的呢？"
>
> 私塾先生据理力争："协议是这样的——无鸡，鸭亦可；无鱼，肉亦可；白菜豆腐不可，少不得束修金。"
>
> 双方唇枪舌战，你来我往，真个是不亦乐乎！
>
> 这里的束修金，也作"束脩"，应当是泛指教师应当得到的报酬

2.2 redis 协议举例

```java
NioEventLoopGroup worker = new NioEventLoopGroup();
byte[] LINE = {13, 10};
try {
    Bootstrap bootstrap = new Bootstrap();
    bootstrap.channel(NioSocketChannel.class);
    bootstrap.group(worker);
    bootstrap.handler(new ChannelInitializer<SocketChannel>() {
        @Override
        protected void initChannel(SocketChannel ch) {
            ch.pipeline().addLast(new LoggingHandler());
            ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                // 会在连接 channel 建立成功后，会触发 active 事件
                @Override
                public void channelActive(ChannelHandlerContext ctx) {
                    set(ctx);
                    get(ctx);
                }
                private void get(ChannelHandlerContext ctx) {
                    ByteBuf buf = ctx.alloc().buffer();
                    buf.writeBytes("*2".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("$3".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("get".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("$3".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("aaa".getBytes());
                    buf.writeBytes(LINE);
                    ctx.writeAndFlush(buf);
                }
                private void set(ChannelHandlerContext ctx) {
                    ByteBuf buf = ctx.alloc().buffer();
                    buf.writeBytes("*3".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("$3".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("set".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("$3".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("aaa".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("$3".getBytes());
                    buf.writeBytes(LINE);
                    buf.writeBytes("bbb".getBytes());
                    buf.writeBytes(LINE);
                    ctx.writeAndFlush(buf);
                }

                @Override
                public void channelRead(ChannelHandlerContext ctx, Object msg)
throws Exception {
                    ByteBuf buf = (ByteBuf) msg;
                    System.out.println(buf.toString(Charset.defaultCharset()));
                }
            });
        }
    });
    ChannelFuture channelFuture = bootstrap.connect("localhost", 6379).sync();
    channelFuture.channel().closeFuture().sync();
} catch (InterruptedException e) {
    log.error("client error", e);
} finally {
    worker.shutdownGracefully();
}
```

2.3 http 协议举例

```
NioEventLoopGroup boss = new NioEventLoopGroup();
NioEventLoopGroup worker = new NioEventLoopGroup();
try {
    ServerBootstrap serverBootstrap = new ServerBootstrap();
    serverBootstrap.channel(NioServerSocketChannel.class);
    serverBootstrap.group(boss, worker);
    serverBootstrap.childHandler(new ChannelInitializer<SocketChannel>() {
        @Override
        protected void initChannel(SocketChannel ch) throws Exception {
            ch.pipeline().addLast(new LoggingHandler(LogLevel.DEBUG));
            ch.pipeline().addLast(new HttpServerCodec());
            ch.pipeline().addLast(new SimpleChannelInboundHandler<HttpRequest>()
{
                @Override
                protected void channelRead0(ChannelHandlerContext ctx,
HttpRequest msg) throws Exception {
                    // 获取请求
                    log.debug(msg.uri());

                    // 返回响应
                    DefaultFullHttpResponse response =
                            new DefaultFullHttpResponse(msg.protocolVersion(),
HttpResponseStatus.OK);

                    byte[] bytes = "<h1>Hello, world!</h1>".getBytes();

                    response.headers().setInt(CONTENT_LENGTH, bytes.length);
                    response.content().writeBytes(bytes);

                    // 写回响应
                    ctx.writeAndFlush(response);
                }
            });
            /*ch.pipeline().addLast(new ChannelInboundHandlerAdapter() {
                @Override
                public void channelRead(ChannelHandlerContext ctx, Object msg)
throws Exception {
                    log.debug("{}", msg.getClass());

                    if (msg instanceof HttpRequest) { // 请求行，请求头

                    } else if (msg instanceof HttpContent) { //请求体

                    }
                }
            });*/
        }
    });
    ChannelFuture channelFuture = serverBootstrap.bind(8080).sync();
    channelFuture.channel().closeFuture().sync();
} catch (InterruptedException e) {
    log.error("server error", e);
} finally {
    boss.shutdownGracefully();
    worker.shutdownGracefully();
}
```

2.4 自定义协议要素

- 魔数，用来在第一时间判定是否是无效数据包
- 版本号，可以支持协议的升级
- 序列化算法，消息正文到底采用哪种序列化反序列化方式，可以由此扩展，例如：json、protobuf、hessian、jdk
- 指令类型，是登录、注册、单聊、群聊... 跟业务相关
- 请求序号，为了双工通信，提供异步能力
- 正文长度
- 消息正文

编解码器

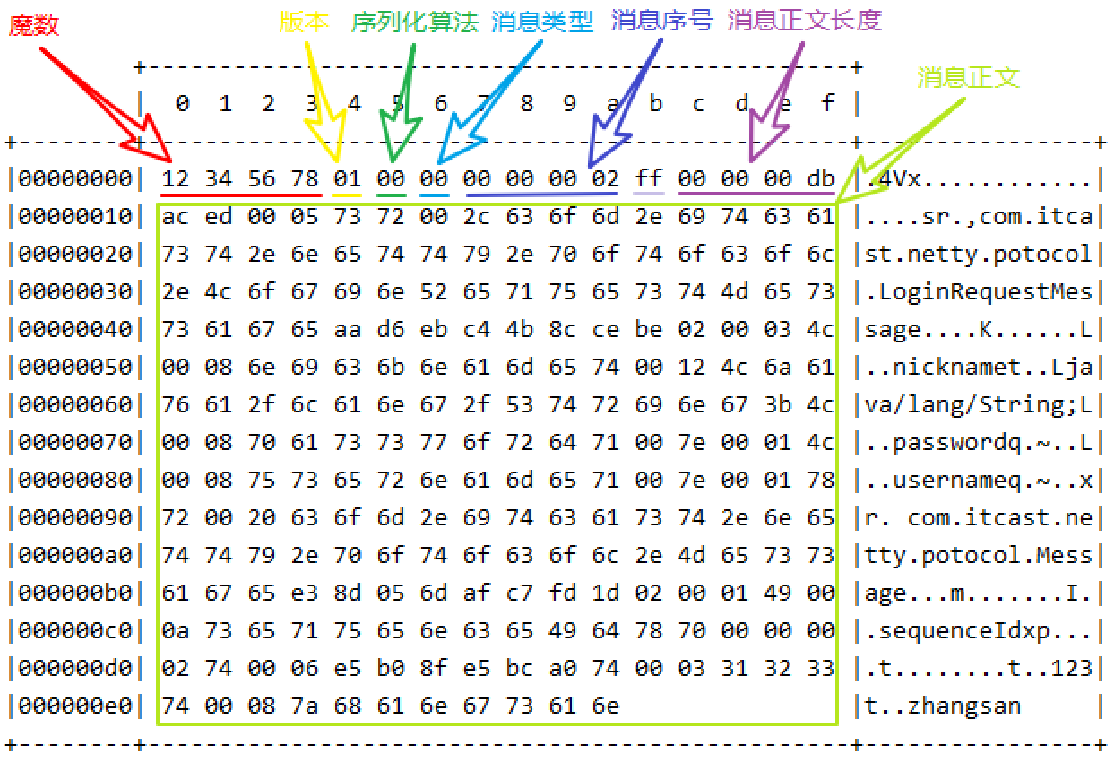
根据上面的要素，设计一个登录请求消息和登录响应消息，并使用 Netty 完成收发

```
@Slf4j
public class MessageCodec extends ByteToMessageCodec<Message> {

    @Override
    protected void encode(ChannelHandlerContext ctx, Message msg, ByteBuf out)
throws Exception {
        // 1. 4 字节的魔数
        out.writeBytes(new byte[]{1, 2, 3, 4});
        // 2. 1 字节的版本,
        out.writeByte(1);
        // 3. 1 字节的序列化方式 jdk 0 , json 1
        out.writeByte(0);
        // 4. 1 字节的指令类型
        out.writeByte(msg.getMessageType());
        // 5. 4 个字节
        out.writeInt(msg.getSequenceId());
        // 无意义，对齐填充
        out.writeByte(0xff);
        // 6. 获取内容的字节数组
        ByteArrayOutputStream bos = new ByteArrayOutputStream();
        ObjectOutputStream oos = new ObjectOutputStream(bos);
        oos.writeObject(msg);
        byte[] bytes = bos.toByteArray();
        // 7. 长度
        out.writeInt(bytes.length);
        // 8. 写入内容
        out.writeBytes(bytes);
    }

    @Override
    protected void decode(ChannelHandlerContext ctx, ByteBuf in, List<Object>
out) throws Exception {
        int magicNum = in.readInt();
        byte version = in.readByte();
        byte serializerType = in.readByte();
        byte messageType = in.readByte();
        int sequenceId = in.readInt();
        in.readByte();
        int length = in.readInt();
        byte[] bytes = new byte[length];
        in.readBytes(bytes, 0, length);
        ObjectInputStream ois = new ObjectInputStream(new
ByteArrayInputStream(bytes));
        Message message = (Message) ois.readObject();
        log.debug("{}, {}, {}, {}, {}, {}", magicNum, version, serializerType,
messageType, sequenceId, length);
        log.debug("{}", message);
        out.add(message);
    }
}
```

测试

```
EmbeddedChannel channel = new EmbeddedChannel(
    new LoggingHandler(),
    new LengthFieldBasedFrameDecoder(
        1024, 12, 4, 0, 0),
    new MessageCodec()
);
// encode
LoginRequestMessage message = new LoginRequestMessage("zhangsan", "123", "张三");
//         channel.writeOutbound(message);
// decode
ByteBuf buf = ByteBufAllocator.DEFAULT.buffer();
new MessageCodec().encode(null, message, buf);

ByteBuf s1 = buf.slice(0, 100);
ByteBuf s2 = buf.slice(100, buf.readableBytes() - 100);
s1.retain(); // 引用计数 2
channel.writeInbound(s1); // release 1
channel.writeInbound(s2);
```

解读



```
         +-------------------------------------------------+
         |  0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f |
+--------+-------------------------------------------------+----------------+
|00000000| 12 34 56 78 01 00 00 00 00 00 02 ff 00 00 00 db |.4Vx............|
|00000010| ac ed 00 05 73 72 00 2c 63 6f 6d 2e 69 74 63 61 |....sr.,com.itca|
|00000020| 73 74 2e 6e 65 74 74 79 2e 70 6f 74 6f 63 6f 6c |st.netty.potocol|
|00000030| 2e 4c 6f 67 69 6e 52 65 71 75 65 73 74 4d 65 73 |.LoginRequestMes|
|00000040| 73 61 67 65 aa d6 eb c4 4b 8c ce be 02 00 03 4c |sage....K......L|
|00000050| 00 08 6e 69 63 6b 6e 61 6d 65 74 00 12 4c 6a 61 |..nicknamet..Lja|
|00000060| 76 61 2f 6c 61 6e 67 2f 53 74 72 69 6e 67 3b 4c |va/lang/String;L|
|00000070| 00 08 70 61 73 73 77 6f 72 64 71 00 7e 00 01 4c |..passwordq.~..L|
|00000080| 00 08 75 73 65 72 6e 61 6d 65 71 00 7e 00 01 78 |..usernameq.~..x|
|00000090| 72 00 20 63 6f 6d 2e 69 74 63 61 73 74 2e 6e 65 |r. com.itcast.ne|
|000000a0| 74 74 79 2e 70 6f 74 6f 63 6f 6c 2e 4d 65 73 73 |tty.potocol.Mess|
|000000b0| 61 67 65 e3 8d 05 6d af c7 fd 1d 02 00 01 49 00 |age...m.......I.|
|000000c0| 0a 73 65 71 75 65 6e 63 65 49 64 78 70 00 00 00 |.sequenceIdxp...|
|000000d0| 02 74 00 06 e5 b0 8f e5 bc a0 74 00 03 31 32 33 |.t........t..123|
|000000e0| 74 00 08 7a 68 61 6e 67 73 61 6e                |t..zhangsan     |
+--------+-------------------------------------------------+----------------+
```

💡 什么时候可以加 @Sharable

- 当 handler 不保存状态时，就可以安全地在多线程下被共享
- 但要注意对于编解码器类，不能继承 ByteToMessageCodec 或 CombinedChannelDuplexHandler 父类，他们的构造方法对 @Sharable 有限制
- 如果能确保编解码器不会保存状态，可以继承 MessageToMessageCodec 父类

```java
@Slf4j
@ChannelHandler.Sharable
/**
 * 必须和 LengthFieldBasedFrameDecoder 一起使用，确保接到的 ByteBuf 消息是完整的
 */
public class MessageCodecSharable extends MessageToMessageCodec<ByteBuf, Message> {
    @Override
    protected void encode(ChannelHandlerContext ctx, Message msg, List<Object> outList) throws Exception {
        ByteBuf out = ctx.alloc().buffer();
        // 1. 4 字节的魔数
        out.writeBytes(new byte[]{1, 2, 3, 4});
        // 2. 1 字节的版本,
        out.writeByte(1);
        // 3. 1 字节的序列化方式 jdk 0 , json 1
        out.writeByte(0);
        // 4. 1 字节的指令类型
        out.writeByte(msg.getMessageType());
        // 5. 4 个字节
        out.writeInt(msg.getSequenceId());
        // 无意义，对齐填充
        out.writeByte(0xff);
        // 6. 获取内容的字节数组
        ByteArrayOutputStream bos = new ByteArrayOutputStream();
        ObjectOutputStream oos = new ObjectOutputStream(bos);
        oos.writeObject(msg);
        byte[] bytes = bos.toByteArray();
        // 7. 长度
        out.writeInt(bytes.length);
        // 8. 写入内容
        out.writeBytes(bytes);
        outList.add(out);
    }

    @Override
    protected void decode(ChannelHandlerContext ctx, ByteBuf in, List<Object>
out) throws Exception {
        int magicNum = in.readInt();
        byte version = in.readByte();
        byte serializerType = in.readByte();
        byte messageType = in.readByte();
        int sequenceId = in.readInt();
        in.readByte();
        int length = in.readInt();
        byte[] bytes = new byte[length];
        in.readBytes(bytes, 0, length);
        ObjectInputStream ois = new ObjectInputStream(new
ByteArrayInputStream(bytes));
        Message message = (Message) ois.readObject();
        log.debug("{}, {}, {}, {}, {}, {}", magicNum, version, serializerType,
messageType, sequenceId, length);
        log.debug("{}", message);
        out.add(message);
    }
}
```

3. 聊天室案例

3.1 聊天室业务介绍

```
/**
 * 用户管理接口
 */
public interface UserService {

    /**
     * 登录
     * @param username 用户名
     * @param password 密码
     * @return 登录成功返回 true, 否则返回 false
     */
    boolean login(String username, String password);
}
```

```
/**
```

```
 * 会话管理接口
 */
public interface Session {

    /**
     * 绑定会话
     * @param channel 哪个 channel 要绑定会话
     * @param username 会话绑定用户
     */
    void bind(Channel channel, String username);

    /**
     * 解绑会话
     * @param channel 哪个 channel 要解绑会话
     */
    void unbind(Channel channel);

    /**
     * 获取属性
     * @param channel 哪个 channel
     * @param name 属性名
     * @return 属性值
     */
    Object getAttribute(Channel channel, String name);

    /**
     * 设置属性
     * @param channel 哪个 channel
     * @param name 属性名
     * @param value 属性值
     */
    void setAttribute(Channel channel, String name, Object value);

    /**
     * 根据用户名获取 channel
     * @param username 用户名
     * @return channel
     */
    Channel getChannel(String username);
}
```

```
/**
 * 聊天组会话管理接口
 */
public interface GroupSession {

    /**
     * 创建一个聊天组, 如果不存在才能创建成功, 否则返回 null
     * @param name 组名
     * @param members 成员
     * @return 成功时返回组对象, 失败返回 null
     */
    Group createGroup(String name, Set<String> members);

    /**
```

```
     * 加入聊天组
     * @param name 组名
     * @param member 成员名
     * @return 如果组不存在返回 null, 否则返回组对象
     */
    Group joinMember(String name, String member);

    /**
     * 移除组成员
     * @param name 组名
     * @param member 成员名
     * @return 如果组不存在返回 null, 否则返回组对象
     */
    Group removeMember(String name, String member);

    /**
     * 移除聊天组
     * @param name 组名
     * @return 如果组不存在返回 null, 否则返回组对象
     */
    Group removeGroup(String name);

    /**
     * 获取组成员
     * @param name 组名
     * @return 成员集合, 没有成员会返回 empty set
     */
    Set<String> getMembers(String name);

    /**
     * 获取组成员的 channel 集合, 只有在线的 channel 才会返回
     * @param name 组名
     * @return 成员 channel 集合
     */
    List<Channel> getMembersChannel(String name);
}
```

3.2 聊天室业务-登录

```
@Slf4j
public class ChatServer {
    public static void main(String[] args) {
        NioEventLoopGroup boss = new NioEventLoopGroup();
        NioEventLoopGroup worker = new NioEventLoopGroup();
        LoggingHandler LOGGING_HANDLER = new LoggingHandler(LogLevel.DEBUG);
        MessageCodecSharable MESSAGE_CODEC = new MessageCodecSharable();
        try {
            ServerBootstrap serverBootstrap = new ServerBootstrap();
            serverBootstrap.channel(NioServerSocketChannel.class);
            serverBootstrap.group(boss, worker);
            serverBootstrap.childHandler(new ChannelInitializer<SocketChannel>()
{
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    ch.pipeline().addLast(new ProcotolFrameDecoder());
```

```java
                        ch.pipeline().addLast(LOGGING_HANDLER);
                        ch.pipeline().addLast(MESSAGE_CODEC);
                        ch.pipeline().addLast(new
SimpleChannelInboundHandler<LoginRequestMessage>() {
                            @Override
                            protected void channelRead0(ChannelHandlerContext ctx,
LoginRequestMessage msg) throws Exception {
                                String username = msg.getUsername();
                                String password = msg.getPassword();
                                boolean login =
UserServiceFactory.getUserService().login(username, password);
                                LoginResponseMessage message;
                                if(login) {
                                    message = new LoginResponseMessage(true, "登录成
功");
                                } else {
                                    message = new LoginResponseMessage(false, "用户名
或密码不正确");
                                }
                                ctx.writeAndFlush(message);
                            }
                        });
                    }
                });
            Channel channel = serverBootstrap.bind(8080).sync().channel();
            channel.closeFuture().sync();
        } catch (InterruptedException e) {
            log.error("server error", e);
        } finally {
            boss.shutdownGracefully();
            worker.shutdownGracefully();
        }
    }
}
```

```java
@Slf4j
public class ChatClient {
    public static void main(String[] args) {
        NioEventLoopGroup group = new NioEventLoopGroup();
        LoggingHandler LOGGING_HANDLER = new LoggingHandler(LogLevel.DEBUG);
        MessageCodecSharable MESSAGE_CODEC = new MessageCodecSharable();
        CountDownLatch WAIT_FOR_LOGIN = new CountDownLatch(1);
        AtomicBoolean LOGIN = new AtomicBoolean(false);
        try {
            Bootstrap bootstrap = new Bootstrap();
            bootstrap.channel(NioSocketChannel.class);
            bootstrap.group(group);
            bootstrap.handler(new ChannelInitializer<SocketChannel>() {
                @Override
                protected void initChannel(SocketChannel ch) throws Exception {
                    ch.pipeline().addLast(new ProcotolFrameDecoder());
//                    ch.pipeline().addLast(LOGGING_HANDLER);
                    ch.pipeline().addLast(MESSAGE_CODEC);
                    ch.pipeline().addLast("client handler", new
ChannelInboundHandlerAdapter() {
```

```
                        // 接收响应消息
                        @Override
                        public void channelRead(ChannelHandlerContext ctx,
Object msg) throws Exception {
                            log.debug("msg: {}", msg);
                            if ((msg instanceof LoginResponseMessage)) {
                                LoginResponseMessage response =
(LoginResponseMessage) msg;
                                if (response.isSuccess()) {
                                    // 如果登录成功
                                    LOGIN.set(true);
                                }
                                // 唤醒 system in 线程
                                WAIT_FOR_LOGIN.countDown();
                            }
                        }

                        // 在连接建立后触发 active 事件
                        @Override
                        public void channelActive(ChannelHandlerContext ctx)
throws Exception {
                            // 负责接收用户在控制台的输入，负责向服务器发送各种消息
                            new Thread(() -> {
                                Scanner scanner = new Scanner(System.in);
                                System.out.println("请输入用户名:");
                                String username = scanner.nextLine();
                                System.out.println("请输入密码:");
                                String password = scanner.nextLine();
                                // 构造消息对象
                                LoginRequestMessage message = new
LoginRequestMessage(username, password);
                                // 发送消息
                                ctx.writeAndFlush(message);
                                System.out.println("等待后续操作...");
                                try {
                                    WAIT_FOR_LOGIN.await();
                                } catch (InterruptedException e) {
                                    e.printStackTrace();
                                }
                                // 如果登录失败
                                if (!LOGIN.get()) {
                                    ctx.channel().close();
                                    return;
                                }
                                while (true) {

 System.out.println("==================================");
                                    System.out.println("send [username]
[content]");
                                    System.out.println("gsend [group name]
[content]");
                                    System.out.println("gcreate [group name]
[m1,m2,m3...]");
                                    System.out.println("gmembers [group name]");
                                    System.out.println("gjoin [group name]");
                                    System.out.println("gquit [group name]");
                                    System.out.println("quit");
 System.out.println("==================================");
                                    String command = scanner.nextLine();
                                    String[] s = command.split(" ");
                                    switch (s[0]){
                                        case "send":
                                            ctx.writeAndFlush(new
ChatRequestMessage(username, s[1], s[2]));
                                            break;
                                        case "gsend":
                                            ctx.writeAndFlush(new
GroupChatRequestMessage(username, s[1], s[2]));
                                            break;
                                        case "gcreate":
                                            Set<String> set = new HashSet<>
(Arrays.asList(s[2].split(",")));
                                            set.add(username); // 加入自己
                                            ctx.writeAndFlush(new
GroupCreateRequestMessage(s[1], set));
                                            break;
                                        case "gmembers":
                                            ctx.writeAndFlush(new
GroupMembersRequestMessage(s[1]));
                                            break;
                                        case "gjoin":
                                            ctx.writeAndFlush(new
GroupJoinRequestMessage(username, s[1]));
                                            break;
                                        case "gquit":
                                            ctx.writeAndFlush(new
GroupQuitRequestMessage(username, s[1]));
                                            break;
                                        case "quit":
                                            ctx.channel().close();
                                            return;
                                    }
                                }
                            }, "system in").start();
                        }
                    });
                }
            });
            Channel channel = bootstrap.connect("localhost",
8080).sync().channel();
            channel.closeFuture().sync();
        } catch (Exception e) {
            log.error("client error", e);
        } finally {
            group.shutdownGracefully();
        }
    }
}
```

3.3 聊天室业务-单聊

服务器端将 handler 独立出来

登录 handler

```
@ChannelHandler.Sharable
public class LoginRequestMessageHandler extends
SimpleChannelInboundHandler<LoginRequestMessage> {
    @Override
    protected void channelRead0(ChannelHandlerContext ctx, LoginRequestMessage
msg) throws Exception {
        String username = msg.getUsername();
        String password = msg.getPassword();
        boolean login = UserServiceFactory.getUserService().login(username,
password);
        LoginResponseMessage message;
        if(login) {
            SessionFactory.getSession().bind(ctx.channel(), username);
            message = new LoginResponseMessage(true, "登录成功");
        } else {
            message = new LoginResponseMessage(false, "用户名或密码不正确");
        }
        ctx.writeAndFlush(message);
    }
}
```

单聊 handler

```
@ChannelHandler.Sharable
public class ChatRequestMessageHandler extends
SimpleChannelInboundHandler<ChatRequestMessage> {
    @Override
    protected void channelRead0(ChannelHandlerContext ctx, ChatRequestMessage
msg) throws Exception {
        String to = msg.getTo();
        Channel channel = SessionFactory.getSession().getChannel(to);
        // 在线
        if(channel != null) {
            channel.writeAndFlush(new ChatResponseMessage(msg.getFrom(),
msg.getContent()));
        }
        // 不在线
        else {
            ctx.writeAndFlush(new ChatResponseMessage(false, "对方用户不存在或者不在
线"));
        }
    }
}
```

3.4 聊天室业务-群聊

创建群聊

```
@ChannelHandler.Sharable
```

```java
public class GroupCreateRequestMessageHandler extends
SimpleChannelInboundHandler<GroupCreateRequestMessage> {
    @Override
    protected void channelRead0(ChannelHandlerContext ctx,
GroupCreateRequestMessage msg) throws Exception {
        String groupName = msg.getGroupName();
        Set<String> members = msg.getMembers();
        // 群管理器
        GroupSession groupSession = GroupSessionFactory.getGroupSession();
        Group group = groupSession.createGroup(groupName, members);
        if (group == null) {
            // 发生成功消息
            ctx.writeAndFlush(new GroupCreateResponseMessage(true, groupName +
"创建成功"));
            // 发送拉群消息
            List<Channel> channels = groupSession.getMembersChannel(groupName);
            for (Channel channel : channels) {
                channel.writeAndFlush(new GroupCreateResponseMessage(true, "您已
被拉入" + groupName));
            }
        } else {
            ctx.writeAndFlush(new GroupCreateResponseMessage(false, groupName +
"已经存在"));
        }
    }
}
```

群聊

```java
@ChannelHandler.Sharable
public class GroupChatRequestMessageHandler extends
SimpleChannelInboundHandler<GroupChatRequestMessage> {
    @Override
    protected void channelRead0(ChannelHandlerContext ctx,
GroupChatRequestMessage msg) throws Exception {
        List<Channel> channels = GroupSessionFactory.getGroupSession()
                .getMembersChannel(msg.getGroupName());

        for (Channel channel : channels) {
            channel.writeAndFlush(new GroupChatResponseMessage(msg.getFrom(),
msg.getContent()));
        }
    }
}
```

加入群聊

```java
@ChannelHandler.Sharable
public class GroupJoinRequestMessageHandler extends
SimpleChannelInboundHandler<GroupJoinRequestMessage> {
    @Override
    protected void channelRead0(ChannelHandlerContext ctx,
GroupJoinRequestMessage msg) throws Exception {
        Group group =
GroupSessionFactory.getGroupSession().joinMember(msg.getGroupName(),
msg.getUsername());
        if (group != null) {
            ctx.writeAndFlush(new GroupJoinResponseMessage(true,
msg.getGroupName() + "群加入成功"));
        } else {
            ctx.writeAndFlush(new GroupJoinResponseMessage(true,
msg.getGroupName() + "群不存在"));
        }
    }
}
```

退出群聊

```java
@ChannelHandler.Sharable
public class GroupQuitRequestMessageHandler extends
SimpleChannelInboundHandler<GroupQuitRequestMessage> {
    @Override
    protected void channelRead0(ChannelHandlerContext ctx,
GroupQuitRequestMessage msg) throws Exception {
        Group group =
GroupSessionFactory.getGroupSession().removeMember(msg.getGroupName(),
msg.getUsername());
        if (group != null) {
            ctx.writeAndFlush(new GroupJoinResponseMessage(true, "已退出群" +
msg.getGroupName()));
        } else {
            ctx.writeAndFlush(new GroupJoinResponseMessage(true,
msg.getGroupName() + "群不存在"));
        }
    }
}
```

查看成员

```java
@ChannelHandler.Sharable
public class GroupMembersRequestMessageHandler extends
SimpleChannelInboundHandler<GroupMembersRequestMessage> {
    @Override
    protected void channelRead0(ChannelHandlerContext ctx,
GroupMembersRequestMessage msg) throws Exception {
        Set<String> members = GroupSessionFactory.getGroupSession()
                .getMembers(msg.getGroupName());
        ctx.writeAndFlush(new GroupMembersResponseMessage(members));
    }
}
```

3.5 聊天室业务-退出

```
@Slf4j
@ChannelHandler.Sharable
public class QuitHandler extends ChannelInboundHandlerAdapter {

    // 当连接断开时触发 inactive 事件
    @Override
    public void channelInactive(ChannelHandlerContext ctx) throws Exception {
        SessionFactory.getSession().unbind(ctx.channel());
        log.debug("{} 已经断开", ctx.channel());
    }

    // 当出现异常时触发
    @Override
    public void exceptionCaught(ChannelHandlerContext ctx, Throwable cause)
throws Exception {
        SessionFactory.getSession().unbind(ctx.channel());
        log.debug("{} 已经异常断开 异常是{}", ctx.channel(), cause.getMessage());
    }
}
```

3.6 聊天室业务-空闲检测

连接假死

原因

- 网络设备出现故障，例如网卡，机房等，底层的 TCP 连接已经断开了，但应用程序没有感知到，仍然占用着资源。
- 公网网络不稳定，出现丢包。如果连续出现丢包，这时现象就是客户端数据发不出去，服务端也一直收不到数据，就这么一直耗着
- 应用程序线程阻塞，无法进行数据读写

问题

- 假死的连接占用的资源不能自动释放
- 向假死的连接发送数据，得到的反馈是发送超时

服务器端解决

- 怎么判断客户端连接是否假死呢？如果能收到客户端数据，说明没有假死。因此策略就可以定为，每隔一段时间就检查这段时间内是否接收到客户端数据，没有就可以判定为连接假死

```
// 用来判断是不是 读空闲时间过长，或 写空闲时间过长
// 5s 内如果没有收到 channel 的数据，会触发一个 IdleState#READER_IDLE 事件
ch.pipeline().addLast(new IdleStateHandler(5, 0, 0));
// ChannelDuplexHandler 可以同时作为入站和出站处理器
ch.pipeline().addLast(new ChannelDuplexHandler() {
    // 用来触发特殊事件
    @Override
    public void userEventTriggered(ChannelHandlerContext ctx, Object evt) throws
Exception{
        IdleStateEvent event = (IdleStateEvent) evt;
        // 触发了读空闲事件
        if (event.state() == IdleState.READER_IDLE) {
            log.debug("已经 5s 没有读到数据了");
            ctx.channel().close();
        }
    }
});
```

客户端定时心跳

- 客户端可以定时向服务器端发送数据，只要这个时间间隔小于服务器定义的空闲检测的时间间隔，那么就能防止前面提到的误判，客户端可以定义如下心跳处理器

```
// 用来判断是不是 读空闲时间过长，或 写空闲时间过长
// 3s 内如果没有向服务器写数据，会触发一个 IdleState#WRITER_IDLE 事件
ch.pipeline().addLast(new IdleStateHandler(0, 3, 0));
// ChannelDuplexHandler 可以同时作为入站和出站处理器
ch.pipeline().addLast(new ChannelDuplexHandler() {
    // 用来触发特殊事件
    @Override
    public void userEventTriggered(ChannelHandlerContext ctx, Object evt) throws
Exception{
        IdleStateEvent event = (IdleStateEvent) evt;
        // 触发了写空闲事件
        if (event.state() == IdleState.WRITER_IDLE) {
            //                                log.debug("3s 没有写数据了，发送一个心
跳包");
            ctx.writeAndFlush(new PingMessage());
        }
    }
});
```