

# Assignment 4

May 30, 2023

## 1 Design

The RMI application is divided into 3 parts: registry, server, client. However, during packaging into Docker image, we need to modify some code in our RMI code.

### 1.1 host and port

Some constants are created due to the property of Docker. The registry (created by Registry) and the service (published by server) on the host 0.0.0.0 and then the request for the registry and services (by client) is from the host *host.docker.internal*, which is the address of the Docker's host, analogous to *localhost* when running directly on the host. The port used to communicate between registry and server or client is self-defined as 1200 so that it is convenient that we can map the port of Docker to port of the host.

```
1 public static final String defaultBindingHost = "0.0.0.0";
2 public static final String defaultAccessingHost = "host.docker.internal";
3 public static final int defaultBindingPort = 1200;
```

Besides, when *exportObject()* in the server, we should explicitly configure its port, which is also for mapping the port of Docker to port of the host.

```
1 MatMulMPI stub = (MatMulMPI) UnicastRemoteObject.exportObject(mmm, 43801);
```

### 1.2 visibility of multi-thread programming

In *UnicastRemoteObject* :: *exportObject()*, we can find that it will be spinning until the port of the skeleton is not 0. The port of the skeleton is modified in the other thread, so if we want to guarantee the port variable is visible after modified in the other thread, we need to add a key word *volatile* on the variable port. However, it does not matter in this assignment since we had configured the port other than 0.

```
1 public static Remote exportObject(Remote obj, String host, int port) throws RemoteException {
2     String interfaceName = obj.getClass().getInterfaces()[0].getName();
3     int objectKey = obj.hashCode();
4
5     RemoteObjectRef ref = new RemoteObjectRef(host, port, objectKey, interfaceName);
6     Skeleton skeleton = new Skeleton(obj, ref);
7     skeleton.start();
8     if (port == 0) {
9         // busy waiting here until port is allocated
10        while (skeleton.getPort() == 0);
11        ref.setPort(skeleton.getPort());
12    }
13    System.out.printf("exportObject to %s:%d\n", host, skeleton.getPort());
14    return Util.createStub(ref);
15 }
```

```
1 private volatile int port;
```

## 2 Screenshots of Docker

The followings are the screenshots as required in instruction. From top to bottom, it is the result of *docker version*, *docker build*, *docker push*, *docker compose*, *docker ps -a* and the running result.

```

lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root$ docker version
Client: Docker Engine - Community
 Cloud integration: v1.0.31
 Version: 23.0.5
 API version: 1.42
 Go version: go1.19.8
 Git commit: bc4487a
 Built: Wed Apr 26 16:17:45 2023
 OS/Arch: linux/amd64
 Context: default

Server: Docker Desktop
Engine:
 Version: 23.0.5
 API version: 1.42 (minimum version 1.12)
 Go version: go1.19.8
 Git commit: 94d3ad6
 Built: Wed Apr 26 16:17:45 2023
 OS/Arch: linux/amd64
 Experimental: false
containerd:
 Version: 1.6.20
 GitCommit: 2806fc1057397dbaeefbea0e4e17bddfdb388f38
runc:
 Version: 1.1.5
 GitCommit: v1.1.5-0-gf19387a
docker-init:
 Version: 0.19.0
 GitCommit: de40ad0

```

Figure 1: Docker version

```

lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root$ cd Registry
lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root/Registry$ docker build -t lynchrocket/my-registry:0.0.1 .
[+] Building 12.2s (10/10) FINISHED
=> [internal] load build definition from Dockerfile                                0.0s
=> => transferring dockerfile: 208B                                              0.0s
=> [internal] load .dockerignore                                                  0.0s
=> => transferring context: 2B                                                  0.0s
=> resolve image config for docker.io/docker/dockerfile:1                      6.0s
=> CACHED docker-image://docker.io/docker/dockerfile:1@sha256:9ba7531bd80fb0a858632727cf7a112fbfd19b17e94c4e84ced81e24ef1a0dbc 0.0s
=> [internal] load metadata for docker.io/library/openjdk:8                    5.9s
=> [internal] load build context                                                  0.0s
=> => transferring context: 34B                                                  0.0s
=> [1/3] FROM docker.io/library/openjdk:8@sha256:86e863cc57215cfb181bd319736dbaf625fe8f150577f9eb58bd937f5452cb8 0.0s
=> CACHED [2/3] COPY ./Registry.jar /registry/registry.jar                    0.0s
=> CACHED [3/3] WORKDIR /registry                                                0.0s
=> exporting to image                                                            0.0s
=> => exporting layers                                                            0.0s
=> writing image sha256:bc30c063f4aa451f346d9e9c9cfb1b797a14bc93a803da0c20a37bd7f7028c9c 0.0s
=> naming to docker.io/lynchrocket/my-registry:0.0.1                          0.0s

```

Figure 2: registry build

```

lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root/Client$ cd ../Server/
lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root/Server$ docker build -t lynchrocket/my-server:0.0.1 .
[+] Building 13.0s (15/15) FINISHED
=> [internal] load build definition from Dockerfile                                0.0s
=> => transferring dockerfile: 635B                                              0.0s
=> [internal] load .dockerignore                                                  0.0s
=> => transferring context: 2B                                                  0.0s
=> resolve image config for docker.io/docker/dockerfile:1                      6.6s
=> CACHED docker-image://docker.io/docker/dockerfile:1@sha256:9ba7531bd80fb0a858632727cf7a112fbfd19b17e94c4e84ced81e24ef1a0dbc 0.0s
=> [internal] load metadata for docker.io/library/openjdk:8                    6.2s
=> [1/8] FROM docker.io/library/openjdk:8@sha256:86e863cc57215cfb181bd319736dbaf625fe8f150577f9eb58bd937f5452cb8 0.0s
=> [internal] load build context                                                  0.0s
=> => transferring context: 62B                                                  0.0s
=> CACHED [2/8] RUN sed -i s@/deb.debian.org/@/mirrors.aliyun.com/@ /etc/apt/sources.list 0.0s
=> CACHED [3/8] RUN apt-get update && apt-get install -y --fix-missing wget software-properties-common build-essential sgml-base rsync xml-core ope 0.0s
=> CACHED [4/8] RUN apt-get install -y --fix-missing cmake git gfortran openmpi-common openmpi-bin libopenmpi-dev && apt-get clean 0.0s
=> CACHED [5/8] COPY ./Server.jar /server/server.jar                          0.0s
=> CACHED [6/8] COPY ./mat_mul.c /server/mat_mul.c                            0.0s
=> CACHED [7/8] WORKDIR /server                                                  0.0s
=> CACHED [8/8] RUN mpicc mat_mul.c -o mat_mul                                  0.0s
=> exporting to image                                                            0.0s
=> => exporting layers                                                            0.0s
=> writing image sha256:9c6133dc5ae3af0c078dcbd52844fa78cc36d7b62b9d840c4c77fa77622eed5d 0.0s
=> naming to docker.io/lynchrocket/my-server:0.0.1                          0.0s

```

Figure 3: server build

```

lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root/Registry$ cd ../Client/
lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root/Client$ docker build -t lynchrocket/my-client:0.0.1 .
[+] Building 14.0s (10/10) FINISHED
=> [internal] load build definition from Dockerfile                                0.0s
=> [internal] load .dockerignore                                                    0.0s
=> [internal] load dockerignore                                                    0.0s
=> [internal] transfer context: 28                                                 0.0s
=> resolve image config for docker.io/docker/dockerfile:1                      6.9s
=> CACHED docker-image://docker.io/docker/dockerfile:1@sha256:9ba7531bd80fb0a858632727cf7a112fbfd19b17e94c4e84ced81e24ef1a0dbc 0.0s
=> [internal] load metadata for docker.io/library/openjdk:8                      6.9s
=> [internal] load build context                                                  0.0s
=> [internal] transfer context: 338                                               0.0s
=> [1/3] FROM docker.io/library/openjdk:8@sha256:86e863cc57215cfb181bd319736d0baf625fe8f158577f9eb58bd937f5452cb8 0.0s
=> CACHED [2/3] COPY ./Client.jar /client/client.jar                             0.0s
=> CACHED [3/3] WORKDIR /client                                                  0.0s
=> exporting to image                                                            0.0s
=> writing image sha256:8d7f8cf85332482a2c10de90831e16bce884ef81f99a6dc82795a12fe05002 0.0s
=> naming to docker.io/lynchrocket/my-client:0.0.1                             0.0s

```

Figure 4: client build

```

lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root$ docker push lynchrocket/my-registry:0.0.1
The push refers to repository [docker.io/lynchrocket/my-registry]
5f70bf18a086: Pushed
a07061d1d712: Pushed
6b5aaff44254: Pushed
53a0b163e995: Pushed
b626401ef603: Pushed
9b55156abf26: Pushed
293d5db30c9f: Pushed
03127cdb479b: Pushed
9c742cd6c7a5: Pushed
0.0.1: digest: sha256:b6e058558ff67876ebb61ef95b6c391436c621a58c7a68c3bb2197e0c88e3d0f size: 2210

```

Figure 5: registry push

```

lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root$ docker push lynchrocket/my-server:0.0.1
The push refers to repository [docker.io/lynchrocket/my-server]
f6aa7fb9c0d4: Pushed
5f70bf18a086: Mounted from lynchrocket/my-registry
696af57bfe94: Pushed
d7ae659d0199: Pushed
bccb7889df66: Pushed
d12e13729b60: Pushed
48c9f02e415e: Pushed
6b5aaff44254: Mounted from lynchrocket/my-registry
53a0b163e995: Mounted from lynchrocket/my-registry
b626401ef603: Mounted from lynchrocket/my-registry
9b55156abf26: Mounted from lynchrocket/my-registry
293d5db30c9f: Mounted from lynchrocket/my-registry
03127cdb479b: Mounted from lynchrocket/my-registry
9c742cd6c7a5: Mounted from lynchrocket/my-registry
0.0.1: digest: sha256:bf91e7cd9bfe78d1b701ed026a8b17b72d55b5343f0002f92c5aead433b016f8 size: 3258

```

Figure 6: server push

```

lynchrocket@LAPTOP-FV00SMG9:~/myrmi-root$ docker push lynchrocket/my-client:0.0.1
The push refers to repository [docker.io/lynchrocket/my-client]
5f70bf18a086: Pushed
fe70cc127688: Pushed
6b5aaff44254: Pushed
53a0b163e995: Pushed
b626401ef603: Pushed
9b55156abf26: Layer already exists
293d5db30c9f: Layer already exists
03127cdb479b: Layer already exists
9c742cd6c7a5: Layer already exists
0.0.1: digest: sha256:6ba3c9793c7c74df631641ac27073e2d5ce4271dd276e5741e65267580fc3637 size: 2210

```

Figure 7: client push

```

lynchrocket@LAPTOP-FV00SNG9:~/myrmi-root/Server$ cd ..
lynchrocket@LAPTOP-FV00SNG9:~/myrmi-root$ docker compose up
[+] Running 4/4
  ✓ Network myrmi-root_default Created 0.6s
  ✓ Container myrmi-registry Created 0.1s
  ✓ Container myrmi-server Created 0.1s
  ✓ Container myrmi-client Created 0.1s
Attaching to myrmi-client, myrmi-registry, myrmi-server
myrmi-registry | Stub created to 0.0.0.0:1200, object key = 0
myrmi-registry | Skeleton created on port 1200
myrmi-server | exportObject to 0.0.0.0:43801
myrmi-server | Stub created to 0.0.0.0:43801, object key = 1163157884
myrmi-server | Skeleton created on port 43801
myrmi-server | Stub created to host.docker.internal:1200, object key = 0
myrmi-server | >>> StubInvocationHandler invoking: rebind
myrmi-registry | RMI Registry is running...RegistryImpl: rebind(MatMul)
myrmi-registry | Skeleton: Invoke void method rebind success
myrmi-server | <<< Finished, code: 1
myrmi-server | RegistryStub Invoke rebind
myrmi-server | Mortgage Server is ready to listen...
myrmi-client | Stub created to host.docker.internal:1200, object key = 0
myrmi-client | connect to host.docker.internal:1200
myrmi-client | >>> StubInvocationHandler invoking: lookup
myrmi-registry | RegistryImpl: lookup(MatMul)
myrmi-registry | Skeleton: Invoke non-void method lookup success
myrmi-client | <<< Finished, code: 2
myrmi-client | RegistryStub Invoke lookup
myrmi-client | Mortgage Server is ready to listen...
myrmi-client | connect to 0.0.0.0:43801
myrmi-client | >>> StubInvocationHandler invoking: calculate
myrmi-server | Done in 0.034841 seconds.
myrmi-server | Correct
myrmi-server | Exited with error code 0
myrmi-server | Skeleton: Invoke non-void method calculate success
myrmi-client | <<< Finished, code: 2
myrmi-client | Calculation finished! Result can be found in the ./result.txt
myrmi-client exited with code 0

```

Figure 8: Docker compose

```

lynchrocket@LAPTOP-FV00SNG9:~$ docker ps -a
CONTAINER ID   IMAGE                                COMMAND                  CREATED        STATUS        PORTS                               NAMES
41c222971548   lynchrocket/my-client:0.0.1         "java -jar client.jar"  29 seconds ago Exited (0) 24 seconds ago         0.0.0.0:1200->1200/tcp, 0.0.0.0:43801->43801/tcp myrmi-client
5d1d1c8a0eb2b   lynchrocket/my-server:0.0.1         "java -jar server.jar"  29 seconds ago Up 27 seconds    0.0.0.0:1200->1200/tcp, 0.0.0.0:43801->43801/tcp myrmi-server
c677faa434cf   lynchrocket/my-registry:0.0.1       "java -jar registry..." 29 seconds ago Up 28 seconds    0.0.0.0:1200->1200/tcp myrmi-registry

```

Figure 9: Docker ps -a

```

myrmi-root > Client > result > result.txt
1 0.00, 41541750.00, 83083500.00, 124625250.00, 166167000.00, 207708750.00, 249250500.00, 290792250.00, 332334000.00, 3
2 0.00, 41666500.00, 83333000.00, 124999500.00, 166666000.00, 208332500.00, 249999000.00, 291665500.00, 333332000.00, 3
3 0.00, 41791250.00, 83582500.00, 125373750.00, 167165000.00, 208956250.00, 250747500.00, 292538750.00, 334330000.00, 3
4 0.00, 41916000.00, 83832000.00, 125748000.00, 167664000.00, 209580000.00, 251496000.00, 293412000.00, 335328000.00, 3
5 0.00, 42040750.00, 84081500.00, 126122250.00, 168163000.00, 210203750.00, 252244500.00, 294285250.00, 336326000.00, 3
6 0.00, 42165500.00, 84331000.00, 126496500.00, 168662000.00, 210827500.00, 252993000.00, 295158500.00, 337324000.00, 3
7 0.00, 42290250.00, 84580500.00, 126870750.00, 169161000.00, 211451250.00, 253741500.00, 296031750.00, 338322000.00, 3
8 0.00, 42415000.00, 84830000.00, 127245000.00, 169660000.00, 212075000.00, 254490000.00, 296905000.00, 339320000.00, 3
9 0.00, 42539750.00, 85079500.00, 127619250.00, 170159000.00, 212698750.00, 255238500.00, 297778250.00, 340318000.00, 3
10 0.00, 42664500.00, 85329000.00, 127993500.00, 170658000.00, 213322500.00, 255987000.00, 298651500.00, 341316000.00, 3
11 0.00, 42789250.00, 85578500.00, 128367750.00, 171157000.00, 213946250.00, 256735500.00, 299524750.00, 342314000.00, 3
12 0.00, 42914000.00, 85828000.00, 128742000.00, 171656000.00, 214570000.00, 257484000.00, 300398000.00, 343312000.00, 3
13 0.00, 43038750.00, 86077500.00, 129116250.00, 172155000.00, 215193750.00, 258232500.00, 301271250.00, 344310000.00, 3
14 0.00, 43163500.00, 86327000.00, 129490500.00, 172654000.00, 215817500.00, 258981000.00, 302144500.00, 345308000.00, 3
15 0.00, 43288250.00, 86576500.00, 129864750.00, 173153000.00, 216441250.00, 259729500.00, 303017750.00, 346306000.00, 3
16 0.00, 43413000.00, 86826000.00, 130239000.00, 173652000.00, 217065000.00, 260478000.00, 303891000.00, 347304000.00, 3
17 0.00, 43537750.00, 87075500.00, 130613250.00, 174151000.00, 217688750.00, 261226500.00, 304764250.00, 348302000.00, 3
18 0.00, 43662500.00, 87325000.00, 130987500.00, 174650000.00, 218312500.00, 261975000.00, 305637500.00, 349300000.00, 3
19 0.00, 43787250.00, 87574500.00, 131361750.00, 175149000.00, 218936250.00, 262723500.00, 306510750.00, 350298000.00, 3
20 0.00, 43912000.00, 87824000.00, 131736000.00, 175648000.00, 219560000.00, 263472000.00, 307384000.00, 351296000.00, 3
21 0.00, 44036750.00, 88073500.00, 132110250.00, 176147000.00, 220183750.00, 264220500.00, 308257250.00, 352294000.00, 3
22 0.00, 44161500.00, 88323000.00, 132484500.00, 176646000.00, 220807500.00, 264969000.00, 309130500.00, 353292000.00, 3
23 0.00, 44286250.00, 88572500.00, 132858750.00, 177145000.00, 221431250.00, 265717500.00, 310003750.00, 354290000.00, 3
24 0.00, 44411000.00, 88822000.00, 133233000.00, 177644000.00, 222055000.00, 266465500.00, 310877000.00, 355288000.00, 3
25 0.00, 44535750.00, 89071500.00, 133607250.00, 178143000.00, 222678750.00, 267213500.00, 311750250.00, 356286000.00, 3
26 0.00, 44660500.00, 89321000.00, 133981500.00, 178642000.00, 223302500.00, 267961500.00, 312623500.00, 357284000.00, 3
27 0.00, 44785250.00, 89570500.00, 134355750.00, 179141000.00, 223926250.00, 268709500.00, 313496750.00, 358282000.00, 3
28 0.00, 44910000.00, 89820000.00, 134730000.00, 179640000.00, 224550000.00, 269457500.00, 314370000.00, 359280000.00, 3
29 0.00, 45034750.00, 90069500.00, 135104250.00, 180139000.00, 225173750.00, 270205500.00, 315243250.00, 360278000.00, 3
30 0.00, 45159500.00, 90319000.00, 135478500.00, 180638000.00, 225797500.00, 270953500.00, 316116500.00, 361276000.00, 3
31 0.00, 45284250.00, 90568500.00, 135852750.00, 181137000.00, 226421250.00, 271701500.00, 316989750.00, 362274000.00, 3
32 0.00, 45409000.00, 90818000.00, 136227000.00, 181636000.00, 227045000.00, 272449500.00, 317863000.00, 363272000.00, 3
33 0.00, 45533750.00, 91067500.00, 136601250.00, 182135000.00, 227668750.00, 273197500.00, 318736250.00, 364270000.00, 3
34 0.00, 45658500.00, 91317000.00, 136975500.00, 182634000.00, 228292500.00, 273945500.00, 319609500.00, 365268000.00, 3
35 0.00, 45783250.00, 91566500.00, 137349750.00, 183133000.00, 228916250.00, 274693500.00, 320482750.00, 366266000.00, 3
36 0.00, 45908000.00, 91816000.00, 137724000.00, 183632000.00, 229540000.00, 275441500.00, 321356000.00, 367264000.00, 3
37 0.00, 46032750.00, 92065500.00, 138098250.00, 184131000.00, 230163750.00, 276189500.00, 322229250.00, 368262000.00, 3
38 0.00, 46157500.00, 92315000.00, 138472500.00, 184630000.00, 230787500.00, 276937500.00, 323102500.00, 369260000.00, 3
39 0.00, 46282250.00, 92564500.00, 138846750.00, 185129000.00, 231411250.00, 277685500.00, 323975750.00, 370258000.00, 3
40 0.00, 46407000.00, 92814000.00, 139221000.00, 185628000.00, 232035000.00, 278433500.00, 324849000.00, 371256000.00, 3
41 0.00, 46531750.00, 93063500.00, 139595250.00, 186127000.00, 232658750.00, 279181500.00, 325722250.00, 372254000.00, 3
42 0.00, 46656500.00, 93313000.00, 140000000.00, 186626000.00, 233282500.00, 279929500.00, 326595500.00, 373252000.00, 3
43 0.00, 46781250.00, 93562500.00, 140374250.00, 187125000.00, 233906250.00, 280677500.00, 327468750.00, 374250000.00, 3
44 0.00, 46906000.00, 93812000.00, 140748500.00, 187624000.00, 234530000.00, 281425500.00, 328342000.00, 375248000.00, 3
45 0.00, 47030750.00, 94061500.00, 141122750.00, 188123000.00, 235153750.00, 282173500.00, 329215250.00, 376246000.00, 3
46 0.00, 47155500.00, 94311000.00, 141497000.00, 188622000.00, 235777500.00, 282921500.00, 330088500.00, 377244000.00, 3
47 0.00, 47280250.00, 94560500.00, 141871250.00, 189121000.00, 236401250.00, 283669500.00, 330961750.00, 378242000.00, 3
48 0.00, 47405000.00, 94810000.00, 142245500.00, 189620000.00, 237025000.00, 284417500.00, 331835000.00, 379240000.00, 3
49 0.00, 47529750.00, 95059500.00, 142619750.00, 190119000.00, 237648750.00, 285165500.00, 332708250.00, 380238000.00, 3
50 0.00, 47654500.00, 95309000.00, 142994000.00, 190618000.00, 238272500.00, 285913500.00, 333581500.00, 381236000.00, 3
51 0.00, 47779250.00, 95558500.00, 143368250.00, 191117000.00, 238896250.00, 286661500.00, 334454750.00, 382234000.00, 3
52 0.00, 47904000.00, 95808000.00, 143742500.00, 191616000.00, 239520000.00, 287409500.00, 335328000.00, 383232000.00, 3
53 0.00, 48028750.00, 96057500.00, 144116750.00, 192115000.00, 240143750.00, 288157500.00, 336201250.00, 384230000.00, 3
54 0.00, 48153500.00, 96307000.00, 144491000.00, 192614000.00, 240767500.00, 288905500.00, 337074500.00, 385228000.00, 3
55 0.00, 48278250.00, 96556500.00, 144865250.00, 193113000.00, 241391250.00, 289653500.00, 337947750.00, 386226000.00, 3
56 0.00, 48403000.00, 96806000.00, 145239500.00, 193612000.00, 242015000.00, 290401500.00, 338821000.00, 387224000.00, 3
57 0.00, 48527750.00, 97055500.00, 145613750.00, 194111000.00, 242638750.00, 291149500.00, 339694250.00, 388222000.00, 3
58 0.00, 48652500.00, 97305000.00, 145988000.00, 194610000.00, 243262500.00, 291897500.00, 340567500.00, 389220000.00, 3
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92 0.00, 52894000.00, 105788000.00, 158712500.00, 211576000.00, 264470000.00, 31732
```

### 3 Dockerfile, docker-compose.yml and Source Code

They are packed in the submission files.

```
1 code --
2     |-- myrmi-root--
3     |               |-- docker-compose.yml # docker compose yaml file
4     |               |-- Registry--
5     |               |               |-- Dockerfile # Dockerfile of registry image
6     |               |               |-- Registry.jar
7     |               |-- Server--
8     |               |               |-- Dockerfile # Dockerfile of server image
9     |               |               |-- mat_mul.c # program of MPI matrix multiplication
10    |               |               |-- Server.jar
11    |               |-- Client--
12    |               |               |-- Dockerfile # Dockerfile of client image
13    |               |               |-- Client.jar
14    |               |               |-- result --
15    |               |               |               |-- result.txt # The calculating result
16    |-- Registry-- # Source code of registry
17    |               |-- ...
18    |-- Server-- # Source code of server
19    |               |-- ...
20    |-- Client-- # Source code of client
21    |               |-- ...
```

### 4 Docker Hub link

<https://hub.docker.com/repositories/lynchrocket>

### 5 Reference

- [1] Java 如何调用 C 语言程序, JNI 技术
- [2] Java Native Interface Specification—Contents
- [3] 【JNI 编程】JNI 数组使用
- [4] idea 打包 Jar 包