OpenTSN Operation Manual

(V1.0)

1. Purpose of the document

This document describes how to set up the OpenTSN demo environment. Required

equipment: 8 openbox_s4, 1 computer with linux system installed, linux system installed and installed

There are 2 computers in the Qt environment, 1 ordinary switch, 1 wired camera, and 1 ordinary computer. The experimental environment

built is shown in Figure 1 below:

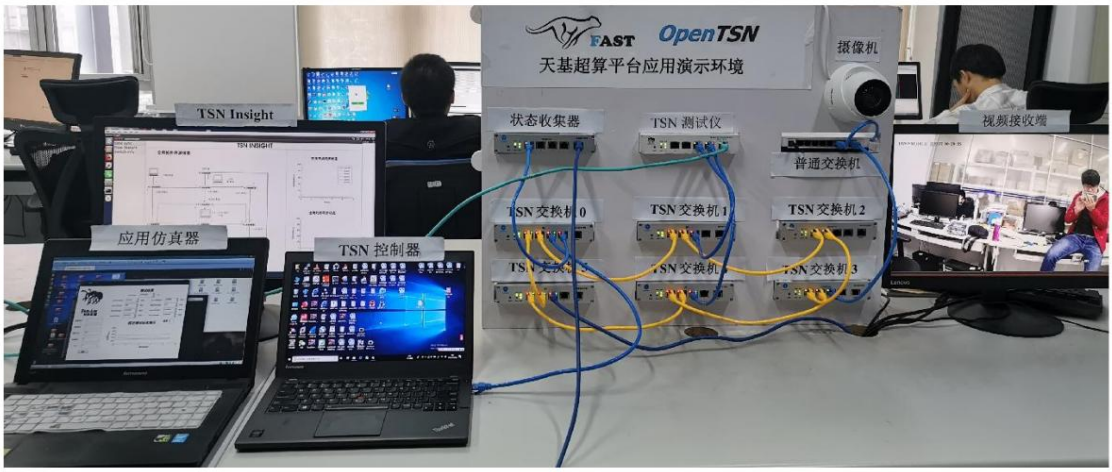

Figure 1 Experimental environment

The effect that the built environment can achieve: (1) The video images transmitted by the camera with no obvious delay and no frame loss can be seen on ordinary computers; (2) The time synchronization accuracy of the current TSN network can be seen on the linux Qt environment ; (3) The relationship between the actual delay and the theoretical delay of the time-sensitive stream transmission in the TSN network can be seen on the Qt environment of linux.

2. Device configuration

2.1 TSN switch

Openbox_s4 is used in the TSN network. The following is a brief introduction to openbox_s4.

2.1.1 Introduction of each interface of openbox_s4

There are 4 data networks, 1 management network, 1 reset button and 4 led lights on the front of openbox_s4, as shown in Figure 2 below:

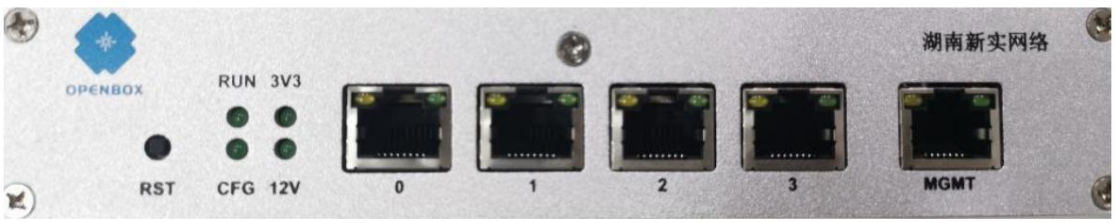

Figure 2 front view of openbox_s4

The back of openbox_s4 has JTAG interface, USB interface, COM serial port, switch and power interface, as shown in Figure 3 below

Show:

Figure 3 back view of openbox_s4

2.1.2 **openbox_s4** is configured as an **OpenTSN** switch

The following steps are described by taking the topology of 6 TSN switching nodes as an example. ÿ Step 1: Download the file Download all the contents in the bin/tsn_switch/ directory, as shown in Figure 4 below:

Figure 4 Download the content of the code cloud

ÿ Step 2: Copy the file to the device (for the copy method, please refer to Appendix 1)

Copy BOOT.bin to the mnt directory in the TF card of openbox-S4, as shown in Figure 5 below:

Figure 5 Copy BOOT.BIN to the mnt directory

Copy S99hnxs.sh, deviceID_config.sh and deviceID to mnt/openbox/config, as shown in Figure 6 below:

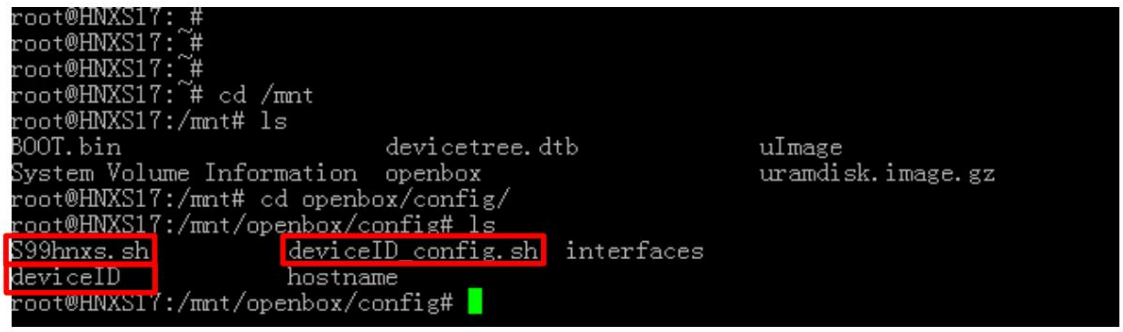

Figure 6 Copy the above three files to mnt/openbox/config ÿ Step 3:

Restart the device by numbering the switch, and log in to the openbox_s4 running interface through the serial port. For details, see Appendix II. Enter the putty interface, as shown in Figure 7 below, and enter the /mnt/openbox/ config directory. The operation command is shown in Figure 8 below:

Figure 7 putty running interface

Figure 8 Enter the /mnt/openbox/config directory

Enter the command "ls" to view all files contained in the current directory, as shown in Figure 9 below:

Figure 9 View the files in the current directory

Enter the command "vi deviceID" (as shown in Figure 13 below) to enter the script "deviceID" file, as shown in Figure 10 below:

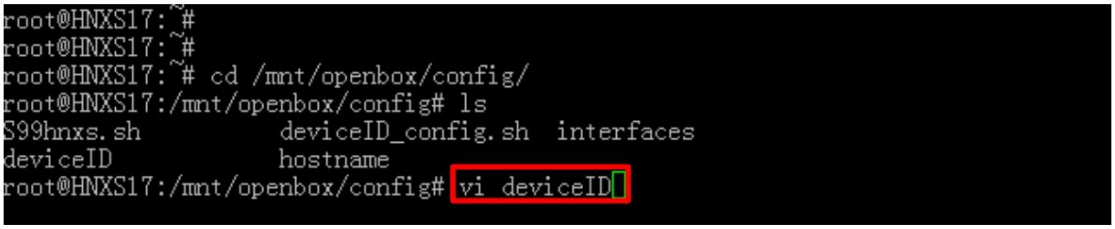

Figure 10 Enter the command "vi deviceID"

Figure 11 Enter the file "deviceID"

The numbers in the red box in Figure 11 above represent the ID of the device and the number of the current TSN switching node. when

There are a total of 6 switch nodes in the former topology, so the 6 openbox_s4s need to be numbered 0 to 5 respectively.

The operation is: press the letter "a" key to modify the number, and modify the 6 openbox_s4 to 0-5 respectively; after the modification is completed, press the "Esc" key, and then press "Shift" + ";" at the same time key, and finally enter "wq".

So far, each openbox_s4 is configured as a TSN switching node.

2.2 Traffic Analyzer (Status Collector)

The traffic analyzer is also done using openbox_s4. The following describes how to set openbox_s4 as a traffic analyzer.

2.2.1 openbox_s4 is configured as a traffic analyzer

ÿ Step 1: Download files Download

all files in the tool/traffic analyzer/ directory, as shown in Figure 12 below:

Figure 12 Download the content of the code cloud

BOOT.bin: The hardware environment in the status

analyzer controller_info: The file configuration connected to the controller, where controller_ip represents the IP address of the Linux device connected to the openbox, and controller_port represents the port number, using the default port number 8080. flow_info: A feature file representing a flow. topology_info: Indicates the topology file. tsn_NA: executable file, which is executed when running the traffic analyzer./tsn_NA ÿ Step 2: Copy the file to the device

Copy all files to the mnt directory of the TF card in openbox-S4, as shown in Figure 13 below:

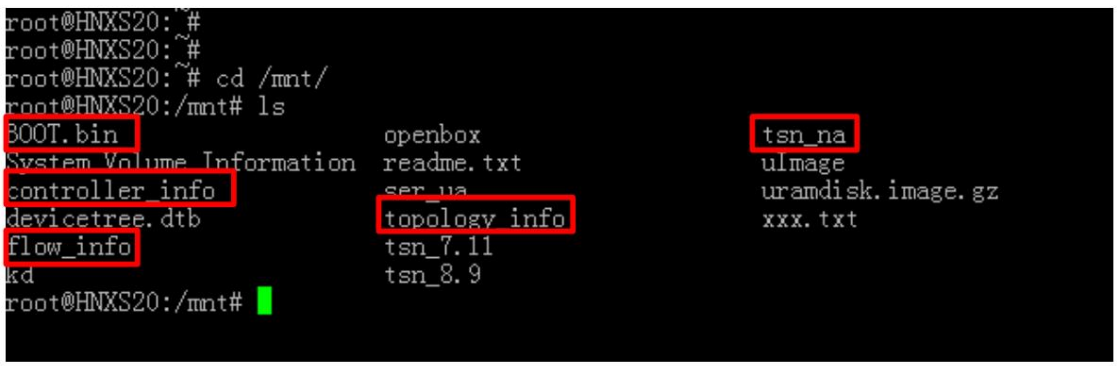

Figure 13 Copy all the above files to the mnt directory

ÿ Step 3: Just restart.

2.3 ANT Tester (TSN Tester)

The ANT tester is also made using openbox_s4. The following describes how to set openbox_s4 as an ANT tester.

2.3.1 openbox_s4 is configured as an **ANT** tester

ÿ Step 1: Download files

Download BOOT.bin, ant and upload.sh files in the tool/ANT tester/ directory, as shown in Figure 14 below:

Figure 14 Download the content of the code cloud

ÿ Step 2: Copy the files to the device Copy

the three downloaded files to the mnt directory of the TF card in openbox-S4, as shown in Figure 15 below:

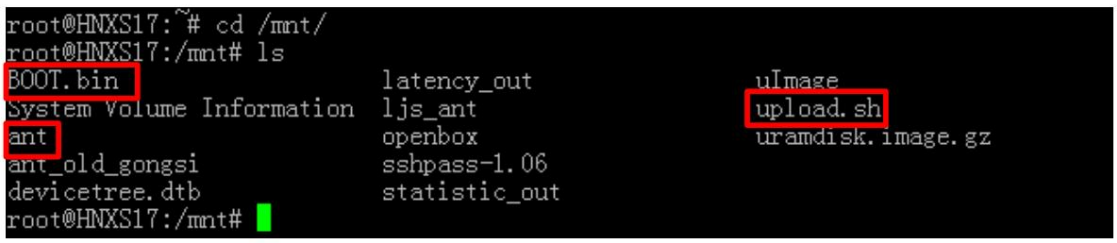

Figure 15 Copy all the above files to the mnt directory

ÿ Step 3: Just restart.

2.4 TSN_CNC (TSN Controller)

TSN_CNC uses a PC with a linux system.

2.4.1 Configuration of TSN_CNC

ÿ Step 1: Download files

Download all files in the bin/tsn_CNC/ directory, as shown in Figure 16 below:

Figure 16 Download the content of the code cloud

ÿ Step 2: Copy the file to the linux system.

2.5 TSN_insight

The control terminal of the tester uses a PC with a linux system, and the Qt environment needs to be installed on the linux system.

2.5.1 Configuration of TSN_insight

ÿ Step 1: Download the file

Download the tsn_insight and TuoPu files in the bin/tsn_insight/ directory, as shown in Figure 17 below, and copy them to the linux device where the Qt environment is installed:

Figure 17 Download the

content of the code cloud ÿ Step 2: Copy the file to the linux system.

2.6 Tester Control Terminal (Application Emulator)

The control terminal of the tester uses a PC equipped with a linux system, and the Qt environment needs to be installed on the linux system.

2.6.1 Configuration of tester control terminal

ÿ Step 1: Download files Download

the ANT and ant.jap files in the tool/ANT tester/GUI/ directory, as shown in Figure 18 below, and copy them to the linux device where the Qt environment is installed:

Figure 18 Download the

content of the code cloud ÿ Step 2: Copy the file to the linux system. ÿ Step 3:

Install ssh-server and ssh-pass services on the linux system. ÿ Step 4: Establish

scp communication between the tester control terminal and the ANT tester. ÿ Step 5:

Execute ./ANT.

2.7 Webcam

The camera is a wired camera. At the same time, a common switch is used as the video receiving end, and the two must be tested before connecting to the network to see if they can be used normally.

3. Device connection

3.1 TSN network connection

According to Section 2.1, each openbox_s4 is numbered 0, 1, 2, 3, 4, 5, which corresponds to TSN switches 0,

TSN switch 1, TSN switch 2, TSN switch 3, TSN switch 4, TSN switch 5. Connect the 6 switches as shown in Figure 19 below:

Figure 19 TSN network connection mode

The specific connection method is: port 1 of switch 0 is connected to port 0 of switch 1, and port 1 of switch 1 is connected to the switch Port 0 of switch 2, port 1 of switch 2 to port 0 of switch 3, port 1 of switch 3 to port 0 of switch 4 port, port 1 of switch 4 is connected to port 0 of switch 5, port 1 of switch 5 is connected to port 0 of switch 0.

3.2 Connection of Traffic Analyzer to TSN Network

The connection between the traffic analyzer and the TSN network is shown in Figure 20 below:

Figure 20 Connection diagram of traffic analyzer and TSN network

The specific connection method is that port 3 of TSN switch 0 is connected to port 0 of the traffic analyzer (status collector), i.e. Can.

3.3 Connection between TSN tester and TSN network

The connection between the ANT tester and the TSN network is shown in Figure 21 below:

Figure 21 Connection diagram of ANT tester and TSN network

The specific connection method is to connect the No. 2 port of the TSN switch 4 to the No. 3 port of the ANT tester (TSN tester), The No. 2 port of TSN switch 1 can be connected to the No. 2 port of the ANT tester (TSN tester).

3.4 Connection between TSN_CNC and TSN network

The connection between TSN_CNC (TSN controller) and TSN network is shown in Figure 22 below:

Figure 22 Connection diagram of TSN_CNC and TSN network

The specific connection method is to connect port 2 of TSN switch 0 to TSN_CNC (TSN controller).

3.5 Connection between TSN_insight and Traffic Analyzer

The connection between TSN_insight and the traffic analyzer (status collector) is shown in Figure 23 below:

Figure 23 Connection diagram of TSN_insight and traffic analyzer

The specific connection method is to connect TSN_insight to the management network port of the status collector (traffic analyzer).

3.6 Connection of Tester Terminal to TSN Tester

The connection method between the tester terminal (application emulator) and the TSN tester is shown in Figure 24 below:

Figure 24 Connection diagram of tester terminal and TSN tester

The specific connection method is to connect the application emulator (tester control terminal) to the management network port of the TSN tester.

3.7 Connection of camera, video receiver and TSN network

The connection method of camera, video receiver and TSN network is shown in Figure 25 below:

Figure 25 Connection diagram of camera, video receiver and TSN network

The specific connection method is to connect the camera to a common switch and then connect the common switch to 2 of TSN switch 3. port, and the video receiver is connected to port 2 of TSN switch 5.

The purpose of using a common switch is to adapt the camera to the TSN network. The reason is that the camera is 100M, and the TSN network is gigabit, so an adaptation is made. If the camera is gigabit, then the camera It is directly connected to port 2 of TSN switch 3.

4. The use of TSN network external device applications

4.1 Use of TSN_CNC

Connect TSN_CNC to the TSN network according to the method in Section 3.4, and execute the following commands on the Linux system of TSN_CNC. The configuration of TSN network by TSN_CNC can be completed by issuing the command. ÿ When executing ./tsn_CNC, the prompt message shown in Figure 26 will appear:

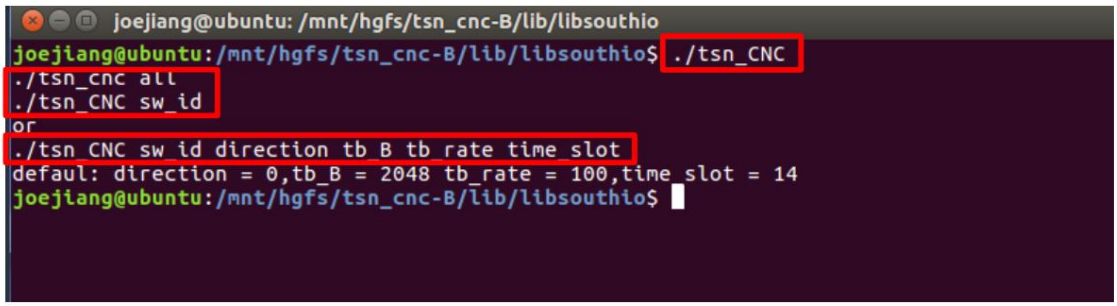

Figure 26 Execute "./tsn_CNC" ÿ

Execute ./tsn_CNC all to configure all switches in the topology, the effect is as shown in Figure 27:

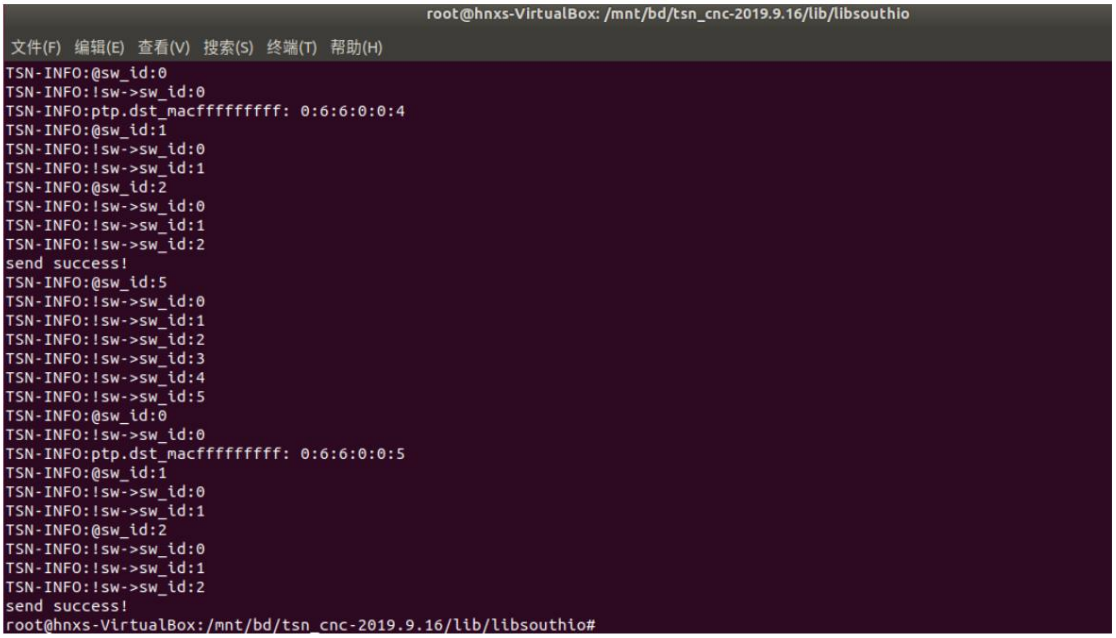

Figure 27 The result of executing "./tsn_CNC all"

ÿ Execute ./tsc_CNC sw_id, sw_id indicates the number of the switch, which is the default configuration for a single switch. For example ./tsn_CNC 0 means default configuration for switch 0.

ÿ Execute ./tsc_CNC sw_id direction tb_B tb_rate time_slot to configure individual switches, where sw_id represents the switch number, direction represents the direction, tb_B represents the bucket depth of the token bucket, tb_rate represents the token bucket rate, and time_slot represents the time slot size , where the time slot size is calculated in nanoseconds to the time_slot power of 2.

4.2 Use of TSN_insight

Connect TSN_insight with the traffic analyzer according to the method of 3.5, and connect TSN_insight under the linux system of TSN_insight.

Log in to the openbox_s4 running interface through the management network port. For the login method, please refer to Appendix 3.

Execute "./tsn_insight" and the following prompt will appear: "please input sw num", where num represents the number of switches.

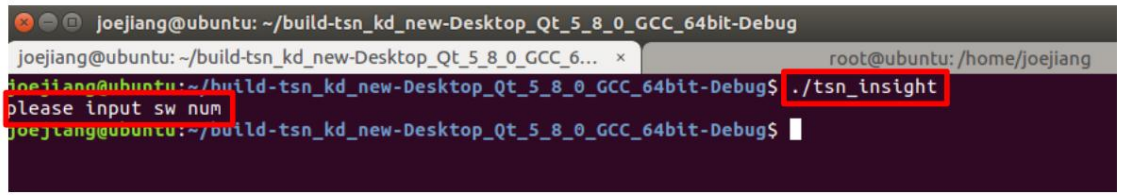

Figure 28 The result of executing "./tsn_insight"

execute "./tsn_insight 6"

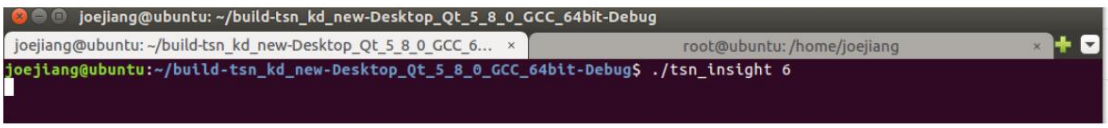

Figure 29 Execute "./tsn_insight 6" to run the terminal

The following interface appears, indicating that tsn_insight has been successfully started

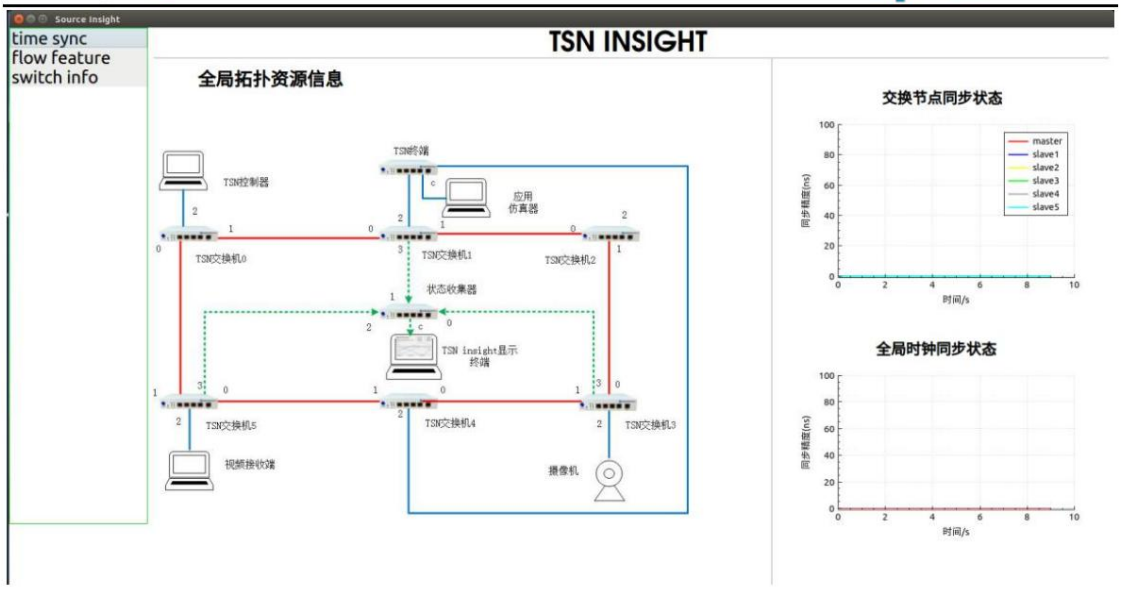

Figure 30 The result of executing "./tsn_insight 6"

In the Linux system of TSN_insight, log in to the openbox_s4 interface through the management network port to control the traffic analyzer (status collector/tsn_na).

For the login method, please refer to Appendix III.

In the /mnt/ directory there are the following contents

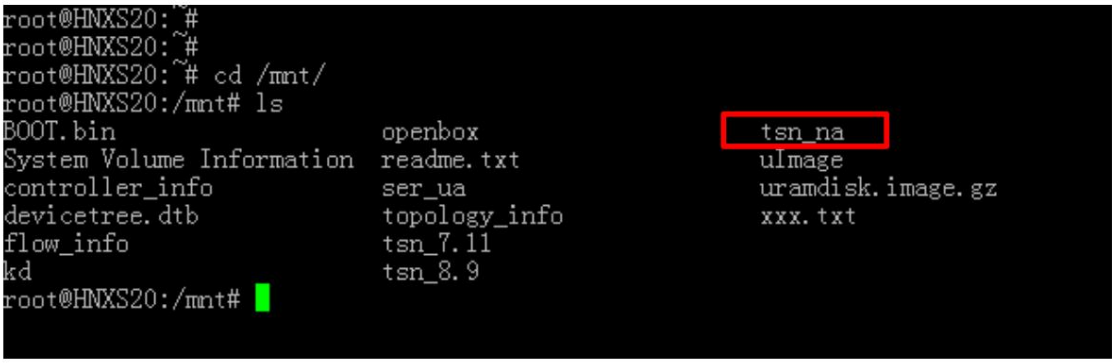

Figure 31 Execute "./tsn_na"

Operation steps

ÿ First run ./tsn_insight 6 in the tsn_insight terminal ÿ Then run ./tsn_na in the

tsn_na terminal

4.3 Use of tester control terminal (application emulator)

Connect the tester control terminal (application emulator) to the TSN terminal (tester) as described in Section 3.6. under test

Put the files in the same directory in the Linux device of the tester control terminal, the required files are as follows ANT and ant.jpg.

Figure 32 Files on Code Cloud

ÿ Step 1: Find the directory under the Linux system of the tester control terminal and execute ./ANT to see the running interface

For the following figure, it means that it can be run.

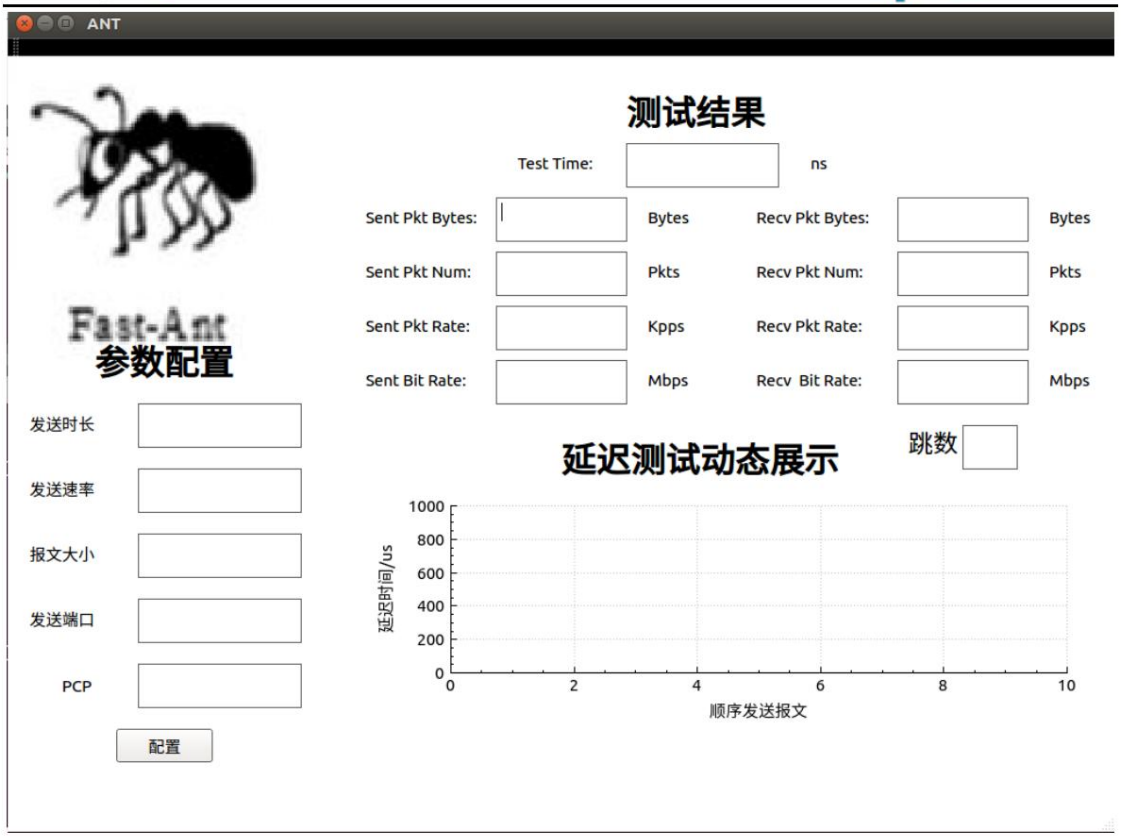

Figure 33 Interface of the tester control

terminal ÿ Step 2: Log in to the tester control terminal (application emulator) under the linux system through the management network port

openbox_s4 interface, used for TSN tester, please refer to appendix 3 for login method. After

logging in, go to the /mnt/ directory, the contents of the directory are as shown below

```
root@HNXS17:~# cd /mnt/
root@HNXS17:/mnt# ls
BOOT.bin                    latency_out                 uImage
System Volume Information   ljs_ant                     upload.sh
ant                         openbox                     uramdisk.image.gz
ant_old_gongsi              sshpass-1.06
devicetree.dtb              statistic_out
root@HNXS17:/mnt#
```

Figure 34 TSN tester running

interface ÿ Step 3: The upload.sh file needs to be modified, the purpose is to transfer the latency_out and statistic_out files in openbox_s4 to the

linux system.

```
root@ubuntu: ~
root@ubuntu: ~ × joejiang@ubuntu: ~/build-ANT-Desktop_Qt_5_8_0_GCC_64bit-Debug ×
#!/bin/bash
#upload.sh
#password = 970904
#user = joejiang
#ip = 192.168.1.110

cd /mnt/sshpass-1.06
./sshpass -p 970904 scp /mnt/latency_out joejiang@192.168.1.30:/home/joejiang/build-ANT-Desktop_Qt_5_8_0_GCC_64bit-Debug
./sshpass -p 970904 scp /mnt/statistic_out joejiang@192.168.1.30:/home/joejiang/build-ANT-Desktop_Qt_5_8_0_GCC_64bit-Debug
~
~
~
~
~
```

Figure 35 Modify the opload.sh file

Contents to be modified:

ÿ 970904 is the password of the Linux machine, ÿ

Joejiang@192.168.1.30:/home/joejiang/..., modify them respectively username, ip, directory in linux, where

The directory should be in the same directory as ANT and ant.jpg.

ÿ Step 4: Send packets on the control terminal of the tester ÿ Run ./ANT

in the Linux terminal ÿ Configure the parameters of the response

Figure 36 Tester control terminal configuration parameters

ÿ Click the Configure button. ÿ

The interface appears as follows, output the number of hops passed

Figure 37 Tester control terminal display interface

4.4 Use of camera

Connect the camera and video receiver to the TSN network according to the method in Section 3.7.

Each receiver has different MAC addresses, so it is necessary to modify the configuration file of TSN_CNC. The specific configuration method is as follows: ÿ

Step 1: Open the topology_info file under the Linux system of TSN_CNC, as shown in the figure below:

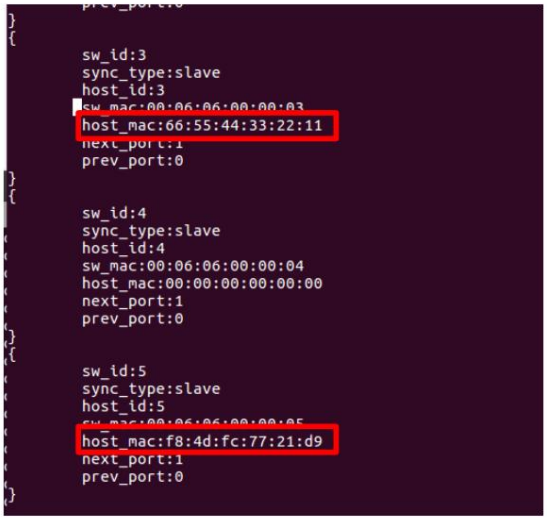

Figure 38 Topology_inso file in TSN_CNC ÿ

Step 2: Modify the host_mac address with sw_id of 3 in the topology file to the mac address of the camera; modify the host_mac address with sw_id of 5 in the topology file to the mac address of the video receiver. ÿ Step 3: Reconfigure the TSN network in TSN_CNC.

Appendix 1: How to copy files into **openbox_s4**

ÿ Step 1: Set the ip address of the linux system device to be in the same network segment as openbox_s4, the specific operation can be found in See Appendix IV.

ÿ Step 2: Use scp to copy files to openbox_s4 in linux system.

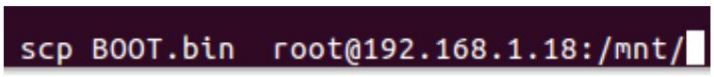

Figure 39 Copy

command where BOOT.bin is the file to be copied, root represents the user name in openbox, 192.168.1.18 represents the IP of the management network port in openbox, please refer to Appendix 4 for the query method of the management network port, /mnt/ is Copy it to the /mnt/ directory in openbox. ÿ Step 3: Enter the password "123123"

Appendix 2: The method of using the serial port to log in to the **openbox_s4** running interface

1) Insert the serial cable into the PC end and the serial port of the openbox_s4 device, and then open the device manager of the computer, as shown below:

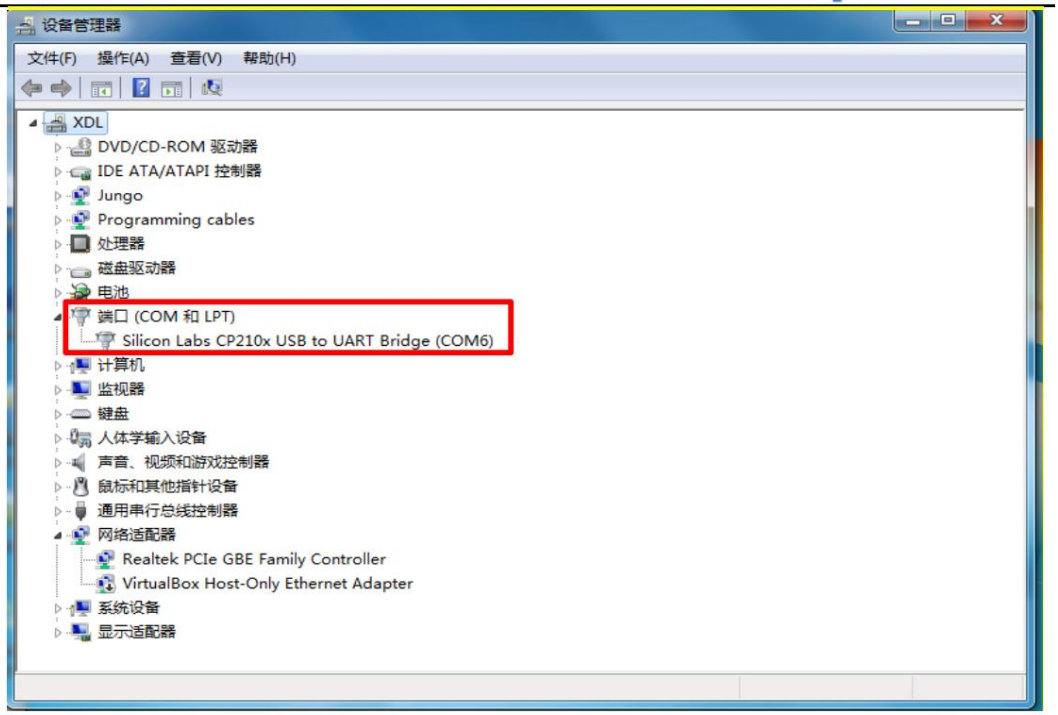

Figure 40 View Device Manager

2) Open the putty software, as shown below:

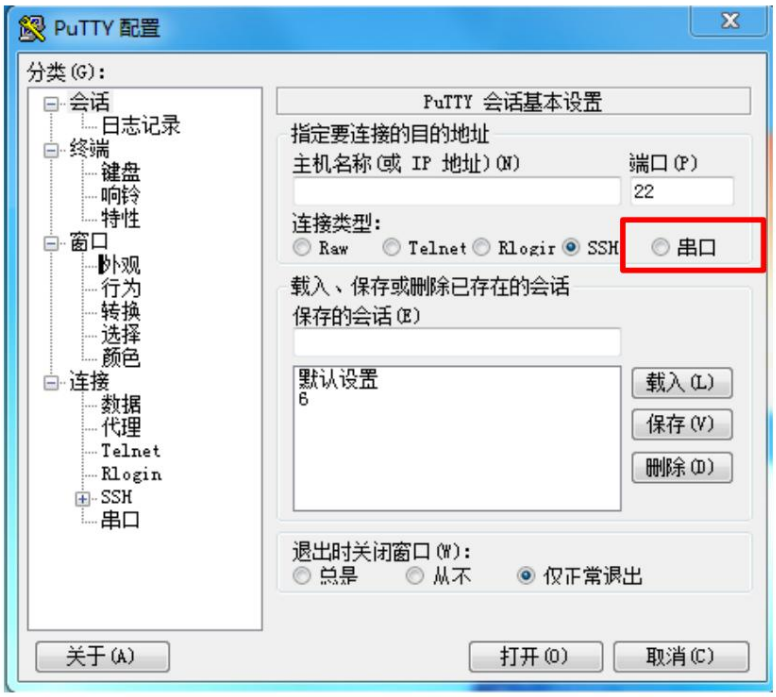

Figure 41 Choose to use serial port to log in on Putty

3) Click the serial port (as shown in the red box in the above picture) option, then the following picture will appear, and change the serial port to be the same as the port name in the device manager in picture 1 (for example: com6 in picture 1, the picture below should be change to com6); change the speed to 115200:

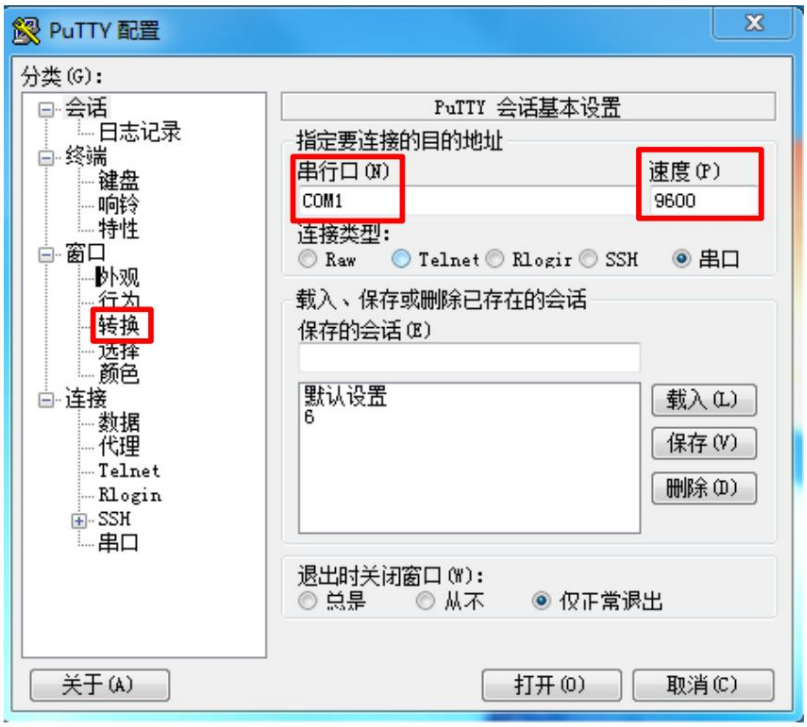

Figure 42 Configure serial port information

4) Then click "Convert" in the left frame of the above figure, and the following figure appears: Then click "Assume the character set of the received data" to select

Select "UTF-8" and click Open.

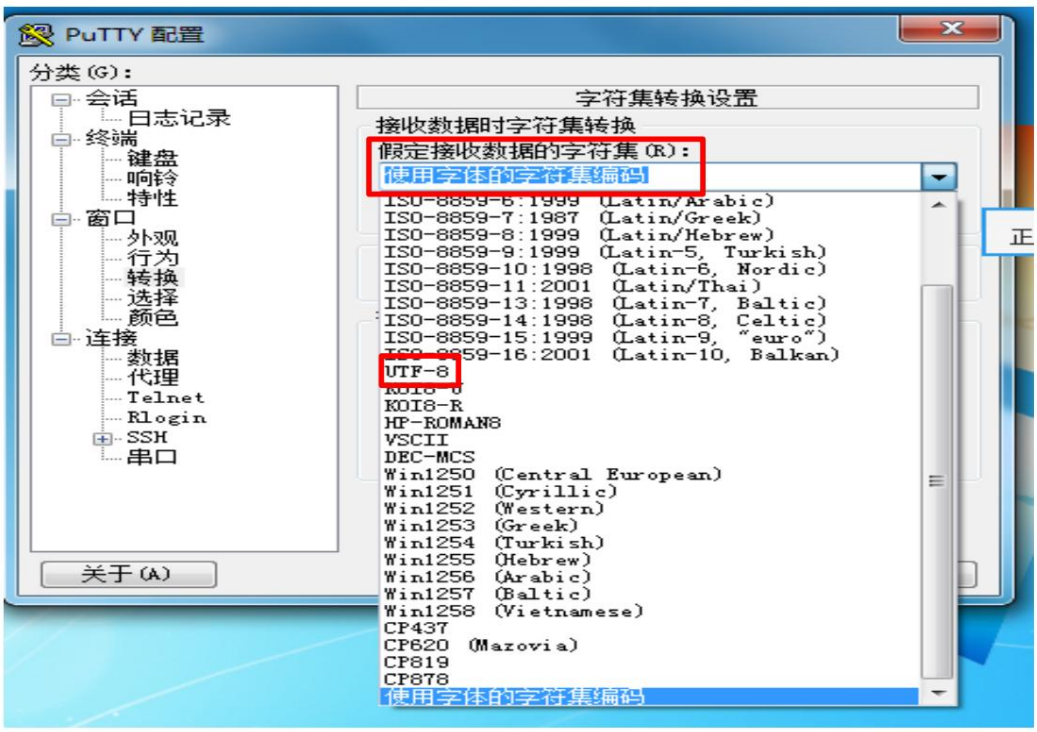

Figure 43 Select character set

Appendix 3: How to use the management network port to log in to the **openbox_s4** running interface

1 Log in to openbox_s4 under windows system

1) Modify the ipv4 address of the PC side to be in the same network segment as the IP address of the management network port of openbox_s4 (for how to check the IP address of openbox_s4, refer to Appendix 4), for example: the IP address of the management network port of openbox_s4 is 192.168.1.18, then the PC The ipv4 address of the terminal is modified to 192.168.1.98 of the same network segment, as shown in the following figure:

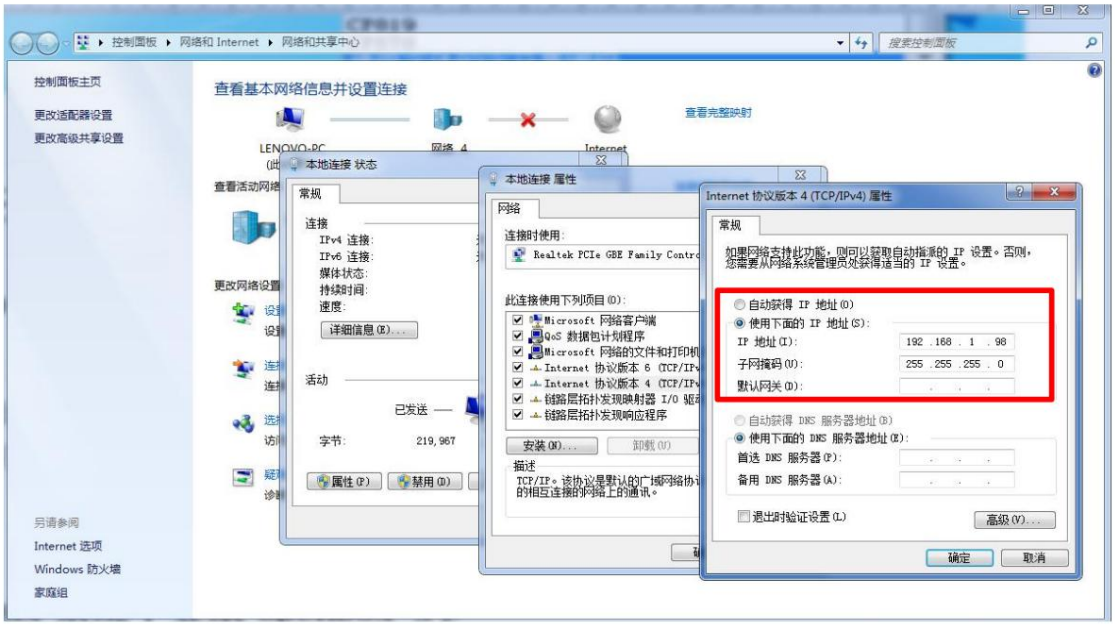

Figure 44 Modify the ip address

of the local device 2) Open the putty software, and output the ip address of openbox_s4 in the "host name (or IP address)" area in the figure below, such as 192.168.1.18 mentioned above; then click Open to log in to on the running interface of openbox_s4.

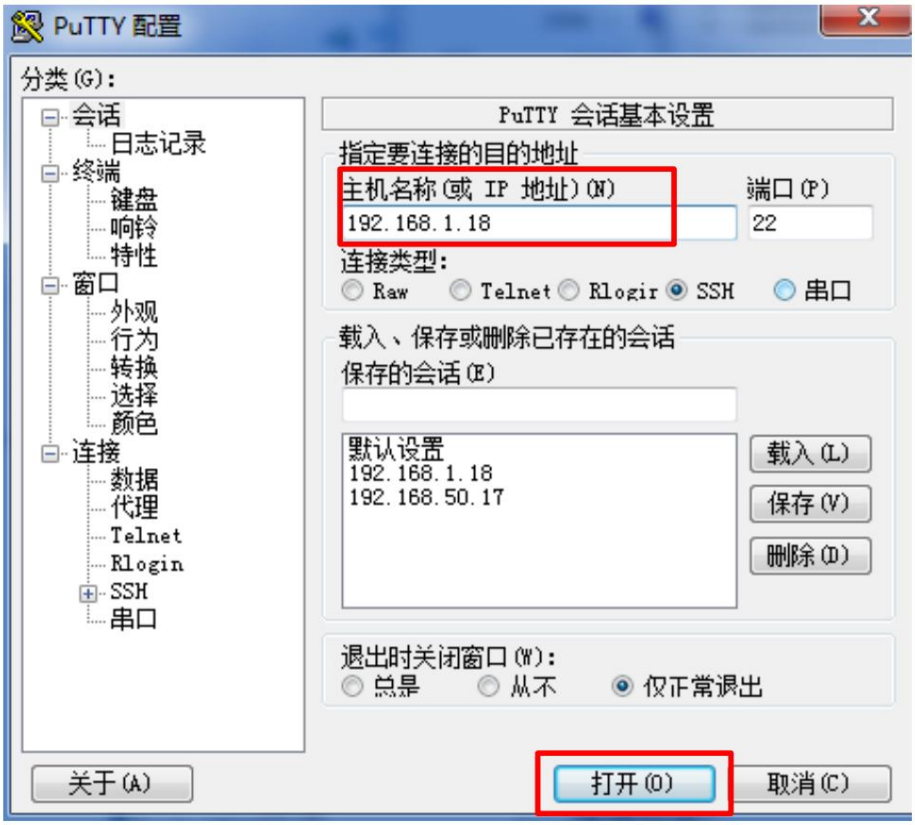

Figure 45 Log in to the ip address of openbox_s4

2 Log in to openbox_s4 under linux system

ÿ Step 1: Execute the following command, which must be executed in the root directory

```
root@ubuntu:~# ssh root@192.168.1.18
```

Figure 46 Execute the login

command ÿ Step 2: 192.168.1.18 is the IP of the management network port, and the interface for entering the password appears

```
root@ubuntu:~# ssh root@192.168.1.18
root@192.168.1.18's password:
```

Figure 47 Enter password

ÿ Step 3: Enter 123123.

Appendix 4: View the **ip** address of **openbox_s4**

ÿ Step 1: Use the serial port to log in to the running interface of openbox_s4, see Appendix 1 for details.

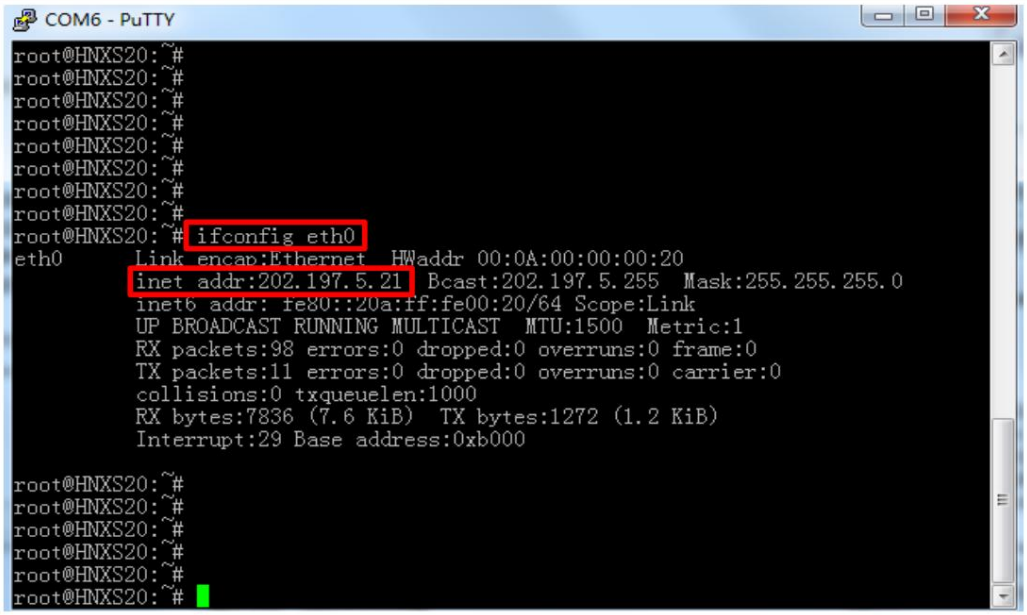

Figure 48 View the IP address of the management network

port of openbox_s4 ÿ Step 2: Enter the command "ifconfic eth0" to view the IP address of the management network port, such as the IP address in the above figure is 202.197.5.21.

Appendix 5: How to use TSNLight source code

Upload the TSNLight source code in the "openTSN/src/software code/TSNLight/" folder, and the user needs to copy it to the linux device installed in the cross-compilation environment for compilation. The topology is divided into ring topology and star topology, and the application is divided into TSN_CNC and TSN_NA. Different parameters are brought into the compilation to compile different topologies and different applications respectively. ÿ Compile ring topology, TSN_CNC application

Execute make TOPOLOGY_TYPE=0 APP_TYPE=CNC

ÿ Compile ring topology, TSN_NA application

Execute make TOPOLOGY_TYPE=0 APP_TYPE=NA

ÿ Compile star topology, TSN_CNC application

Execute make TOPOLOGY_TYPE=1 APP_TYPE=CNC

ÿ Compile star topology, TSN_NA applications

Execute make TOPOLOGY_TYPE=1 APP_TYPE=NA to generate tsn_controller executable file after compiling.

Appendix VI: Configuration Instructions

The tsn network configuration form includes the form of the command line and the form of the configuration file, where the form of the command line is the parameters carried later when the tsn_cnc application is executed, and the parameters include the size of the time slot, the bucket depth of the token bucket and the rate (For detailed configuration information, please refer to Section 4.1 Use of TSN_CNC); the configuration file includes topology_info and flow_info files.

The topology_info file saves the topology information of the network, including the number and mac address of the switch. Users can organize their own network according to their needs, and then fill in the network information into this file, and then the controller generates configuration information and configures it into the network. ;flow_info saves the current flow characteristic information, including BE, RC and TSN flow.

The contents of the topology_info file are as follows

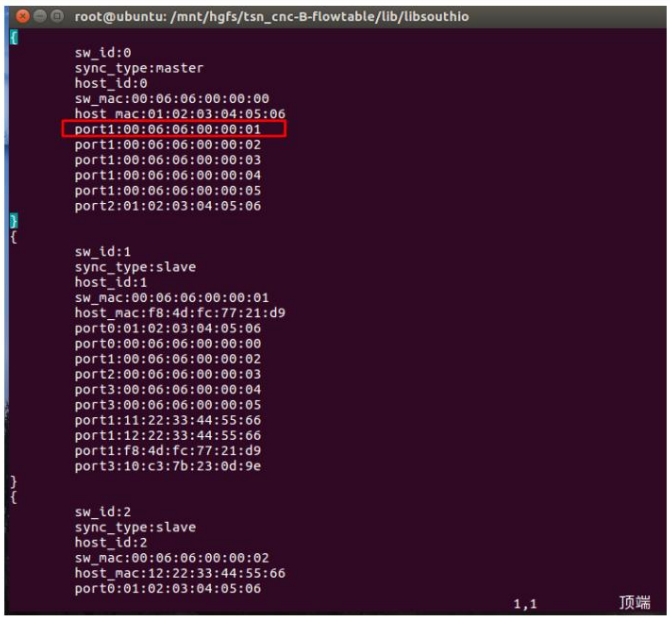

Figure 49 Topology_info file content

Among them, sw_id represents the ID of the switch, starting from 0 and numbering in sequence; sync_type represents the type of the device, which is used for the configuration of the master and slave devices, including master and slave; host_id represents the ID number of the host connected to the switch, generally from 0 Start means; sw_mac represents the mac address of the switch; host_mac represents the mac address of the switch connected to the host; port* represents the message whose destination mac address needs to be forwarded from the * port with the following parameters, such as in the red block diagram above, if the switch receives To the message whose destination mac address is 00:06:06:00:00:01, it will be forwarded from port 1. If the port has no message to be forwarded, it is not required to fill in. If the port needs to forward multiple messages text, you need to list them all. The content of the flow_info file is as follows (currently the flow features are used for interface display, not for configuration):

Figure 50 topology_info file content

The type field identifies the type of traffic, including three traffic types: tsn, rc, and be; flow_id is used to uniquely identify the flow ID, and the three types of traffic are uniformly identified, generally starting from 0; the src_mac field indicates the source mac of the packet address; the dst_mac field indicates the destination mac address of the packet; the priority field indicates the priority, where the priority of the tsn flow is 6 and 7, the priority of the rc flow is 3, 4 and 5, and the priority of the be flow is 0, 1 and 2 ;The interval field represents the traffic sending cycle; pkt_num represents the number of packets sent in each cycle; pkt_size represents the size of each packet; bandwidth.