Multimaster ROS configuration and multimaster_fkie

Aug 27, 2018 • Yaoyu Hu

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ROS version: Luna.

OS: Ubuntu 16.04.

multimaster_fkie: github, master, tag 0.8.2. (github repo)

1 Network configuration

1.1 Router

- Setup a wireless router and connect two computers/robots.
- Setup static IP addresses for those two computers.
- Test ping command and ssh mutually.

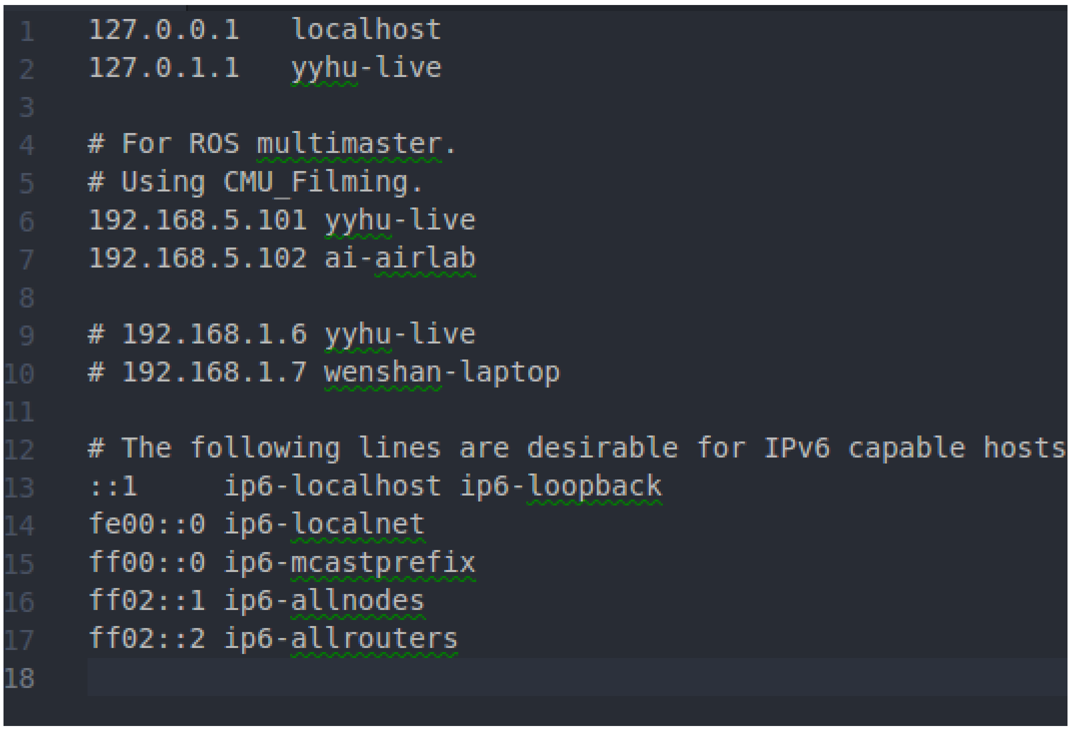
1.2 Hosts

Let's define the computer 0 as the master computer C0, let computer 1 be the client computer C1.

On C0 and C1, backup their /etc/hosts files and modify these file to register their IP addresses.

NOTE: It would be a better idea that we just use the computer name as the hostname of C0 and C1. Here, the "computer name" is the name appears next to "127.0.1.1" in the /etc/hosts file. ROS and node_manager of multimaster_fkie treat different kinds "hostname" in different ways. Just do not try to "configure" them. You'd better double check if the content of /etc/hostname is consistent with the names in /etc/hosts.

A sample /etc/hosts file looks like the following one shown in figure 1. Now let's use my own computer as C0 (hostname: yyhu-live). The client computer as C1 (hostname: ai-airlab).



```
127.0.0.1	localhost
127.0.1.1	yyhu-live

# For ROS multimaster.
# Using CMU_Filming.
192.168.5.101 yyhu-live
192.168.5.102 ai-airlab

# 192.168.1.6 yyhu-live
# 192.168.1.7 wenshan-laptop

# The following lines are desirable for IPv6 capable hosts
::1     ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

```

Figure 1 Sample /etc/hosts file on C0. ↑ yyhu-live is my computer's hostname. 127.0.0.1 and 192.168.5.101 are assigned an identical hostname.

Ping C0 and C1 using the newly defined hostnames from each side.

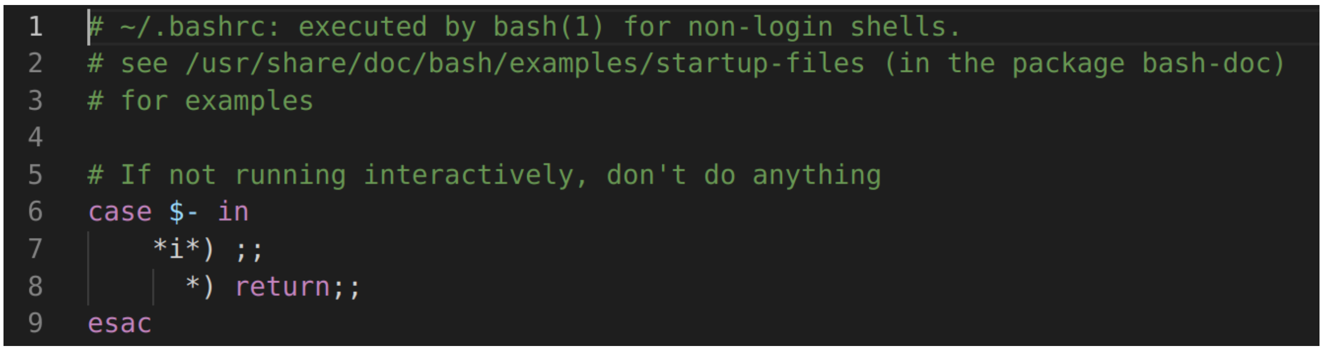
1.3 ROS network

This section is composed by mainly referring to this pdf. ("Multi-master ROS systems" by Sergi Hernandez Juan & Fernando Herrero Cotarelo)

On each computer put this line into their .bashrc file.

```
export ROS_MASTER_URI=http://yyhu-live:11311
```

To use ROS over SSH, on the Ubuntu 16 system, the user has to comment the following lines in their .bashrc file as shown in figure 2. (Reference here. The official website of multimaster_fkie also mentioned this issue.)



```
1 # ~/.bashrc: executed by bash(1) for non-login shells.
2 # see /usr/share/doc/bash/examples/startup-files (in the package bash-doc)
3 # for examples
4 
5 # If not running interactively, don't do anything
6 case $- in
7     *i*) ;;
8       *) return;;
9 esac
```

Figure 2 Lines to be commented in .bashrc file. (Line 6 to 9.) ↑

NOTE: Ignore the following table.

```
On the master computer, C0,
export ROS_HOSTNAME=<C0's hostname>

(C1 will try to get access to /roslaunch/uris/host_ros_c0__<pid>, if th

(The above solution faces another issue. The client computer C1 could s

To summarize, ROS_MASTER_URI tells a node where to find the master. ROS

Reference:
ROS official documentation.
ROS Answers.
```

Use the following command on every computer to check if the multicast function is enabled.

```
cat /proc/sys/net/ipv4/icmp_echo_ignore_broadcasts
```

Use the following command on every computer to enable the multicast function temporarily.

```
sudo sh -c "echo 0 > /proc/sys/net/ipv4/icmp_echo_ignore_broadcasts"
```

To permanently enable the multicast function, edit /etc/sysctl.conf file, add the following line.

```
net.ipv4.icmp_echo_ignore_broadcasts=0
```

And use the following command to restart the relevant service.

```
sudo service procps restart
```

Use this command to show the currently defined multicast groups. Normally, there should be a 224.0.0.1 group.

```
netstat -g
```

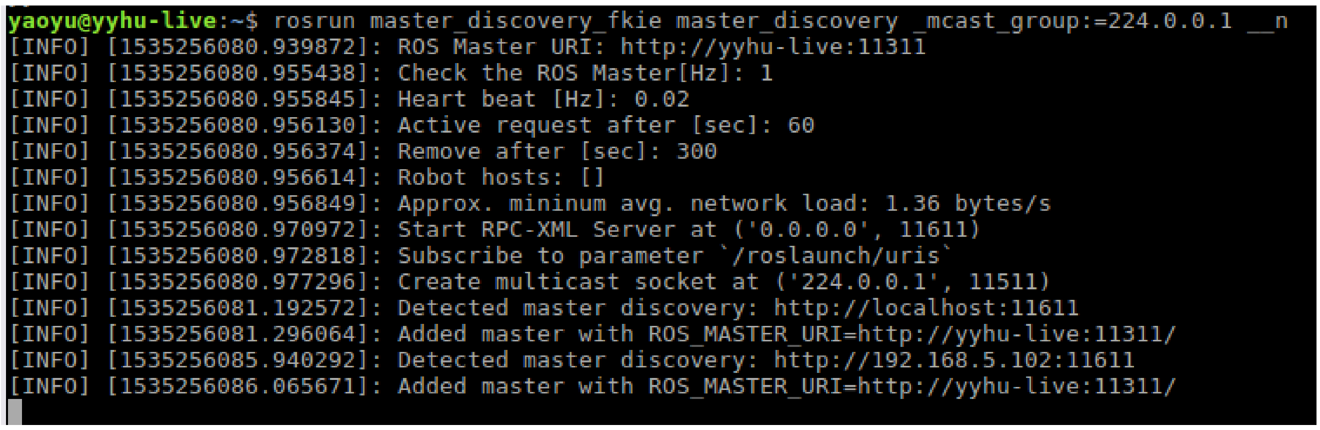
Use this command to see if all the computers respond to the broadcast.

```
ping 224.0.0.1
```

1.4 Test the usability of multimaster ROS network

On C0 start roscore, then start the master_discovery node. The terminal output is in figure 3.

```
rosrun master_discovery_fkie master_discovery _mcast_group:=224.0.0.1
```



```
yaoyu@yyhu-live:~$ rosrun master_discovery_fkie master_discovery _mcast_group:=224.0.0.1 __n
[INFO] [1535256080.939872]: ROS Master URI: http://yyhu-live:11311
[INFO] [1535256080.955438]: Check the ROS Master[Hz]: 1
[INFO] [1535256080.955845]: Heart beat [Hz]: 0.02
[INFO] [1535256080.956130]: Active request after [sec]: 60
[INFO] [1535256080.956374]: Remove after [sec]: 300
[INFO] [1535256080.956614]: Robot hosts: []
[INFO] [1535256080.956849]: Approx. mininum avg. network load: 1.36 bytes/s
[INFO] [1535256080.970972]: Start RPC-XML Server at ('0.0.0.0', 11611)
[INFO] [1535256080.972818]: Subscribe to parameter `/roslaunch/uris`
[INFO] [1535256080.977296]: Create multicast socket at ('224.0.0.1', 11511)
[INFO] [1535256081.192572]: Detected master discovery: http://localhost:11611
[INFO] [1535256081.296064]: Added master with ROS_MASTER_URI=http://yyhu-live:11311/
[INFO] [1535256085.940292]: Detected master discovery: http://192.168.5.102:11611
[INFO] [1535256086.065671]: Added master with ROS_MASTER_URI=http://yyhu-live:11311/
```

Figure 3 Terminal output after starting master_discovery node on C0. ↑

On C1, WITHOUT starting a roscore, start the same node with a different node name. (Reference.)

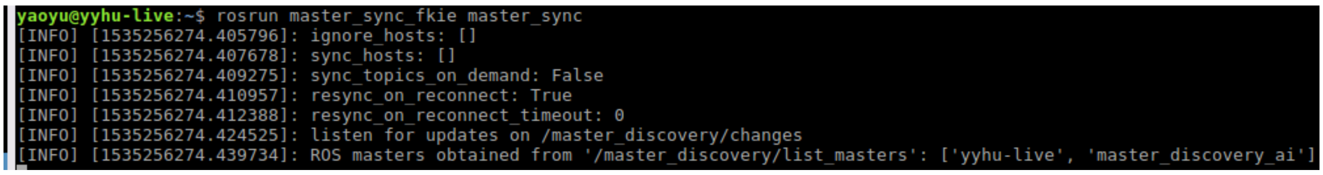
```
rosrun master_discovery_fkie master_discovery _mcast_group:=224.0.0.1 _
```

NOTE: There are TWO underscores before the name parameter.

If the node names are the same, C0 will complain about this situation and terminate itself.

On C0 start master_sync node (terminal output is shown in figure 4).

```
rosrun master_sync_fkie master_sync
```



```
yaoyu@yyhu-live:~$ rosrun master_sync_fkie master_sync
[INFO] [1535256274.405796]: ignore_hosts: []
[INFO] [1535256274.407678]: sync_hosts: []
[INFO] [1535256274.409275]: sync_topics_on_demand: False
[INFO] [1535256274.410957]: resync_on_reconnect: True
[INFO] [1535256274.412388]: resync_on_reconnect_timeout: 0
[INFO] [1535256274.424525]: listen for updates on /master_discovery/changes
[INFO] [1535256274.439734]: ROS masters obtained from '/master_discovery/list_masters': ['yyhu-live', 'master_discovery_ai']
```

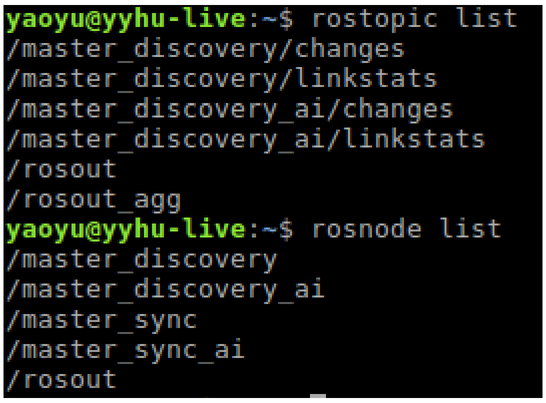
Figure 4 Terminal output after starting master_sync node no C0. ↑

On C1 start master_sync node with a different node name.

```
rosrun master_sync_fkie master_sync __name:=master_sync_ai
```

At the moment, each master_sync node should print synchronization information. This information will be refreshed in an interval of several seconds.

List the current topics and node by "rostopic list" and "rosnode list" on each computer, one should see the same results. It is illustrated in figure 5.



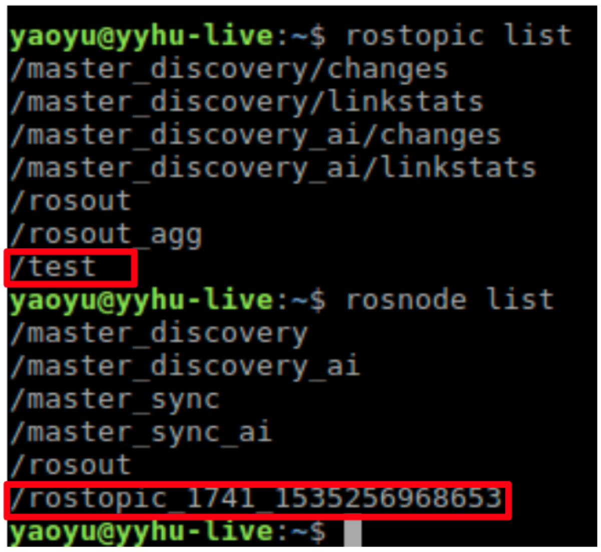
```
yaoyu@yyhu-live:~$ rostopic list
/master_discovery/changes
/master_discovery/linkstats
/master_discovery_ai/changes
/master_discovery_ai/linkstats
/rosout
/rosout_agg
yaoyu@yyhu-live:~$ rosnode list
/master_discovery
/master_discovery_ai
/master_sync
/master_sync_ai
/rosout
```

Figure 5 List of topics and nodes. Executed on C0. ↑

If everything works, now let's try to publish and subscribe real data. On any of the two computers, start an anonymous node using the following command.

```
rostopic pub -r 1 /test std_msgs/Int32 1
```

The above command will start an anonymous node and advertise a topic with the name "/test". This node will publish an Int32 type value, 1, every second. Now use "rostopic list" and "rosnode list" to see if the new topic and node exist. The results will be similar to figure 6.



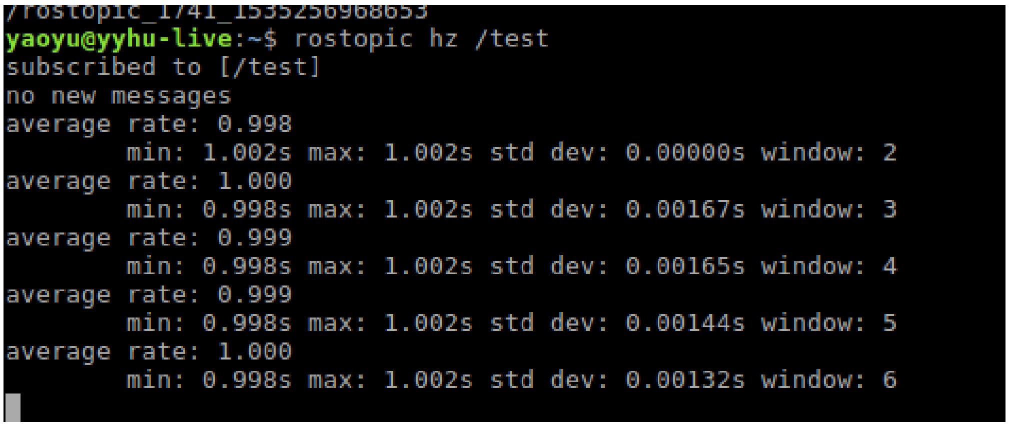
```
yaoyu@yyhu-live:~$ rostopic list
/master_discovery/changes
/master_discovery/linkstats
/master_discovery_ai/changes
/master_discovery_ai/linkstats
/rosout
/rosout_agg
/test
yaoyu@yyhu-live:~$ rosnode list
/master_discovery
/master_discovery_ai
/master_sync
/master_sync_ai
/rosout
/rostopic_1741_1535256968653
yaoyu@yyhu-live:~$
```

Figure 6 The new anonymous node. ↑

If /test is on C1, use

```
rostopic hz /test
```

on C0 to see if C0 could really receive any actual data. The results are in figure 7.



```
/rostopic_1741_1535256968653
yaoyu@yyhu-live:~$ rostopic hz /test
subscribed to [/test]
no new messages
average rate: 0.998
        min: 1.002s max: 1.002s std dev: 0.00000s window: 2
average rate: 1.000
        min: 0.998s max: 1.002s std dev: 0.00167s window: 3
average rate: 0.999
        min: 0.998s max: 1.002s std dev: 0.00165s window: 4
average rate: 0.999
        min: 0.998s max: 1.002s std dev: 0.00144s window: 5
average rate: 1.000
        min: 0.998s max: 1.002s std dev: 0.00132s window: 6
```

Figure 7 Frequency test on a ROS topic. ↑

2 node_manager GUI

Now we have configured a working multimaster ROS network, we could use node_manager GUI to visualize the information of the nodes in the ROS network and interact with those nodes.

2.1 Prepare a test ROS node

We will test some functionalities of node_manager, this needs a sample ROS node to work with.

A simple ROS node is created. This node will simply publish a string message every second. This node is written in Python and a launch file should be prepared. The associated ROS package is called "test_pub", and the Python script is called "simple_pub.py". The script and launch files could be found here.

Since node_manager heavily relies on the tool named "screen", we have to install in on our system.

For now, any ROS node should be launched in a "screen". node_manager assumes that a "screen" has a specific "name" which is associated with the "name" of the ROS node. We have to explicitly specify the "screen name" and the "ROS node name" when launching a ROS node in "screen". Using the test_pub package as an example, we use the following command to launch its ROS node (a running roscore on C0 is required since we've configured the system-wide ROS_MASTER_URI).

```
screen -S _simple_pub_launch -dm roslaunch test_pub simple_pub.launch
```

where -S argument of "screen" specifies the name of the "screen" and -dm argument of "screen" tells "screen" to start in the detached mode an execute the command specified as the rest of the command line arguments. Note that there is a space character between the -S argument and the name of the "screen". Once this command is issued, one could use

```
screen -ls
```

to see if the launch works well and the name of the “screen” is properly set.

Store this sample node on C1 for later use.

2.2 Test node_manager

Now stop any running nodes on C0 and C1, leaving the roscore on C0 running. On C0, start node_manager by

```
node_manager
```

As shown in figure 8, the GUI of node_manager will show up.

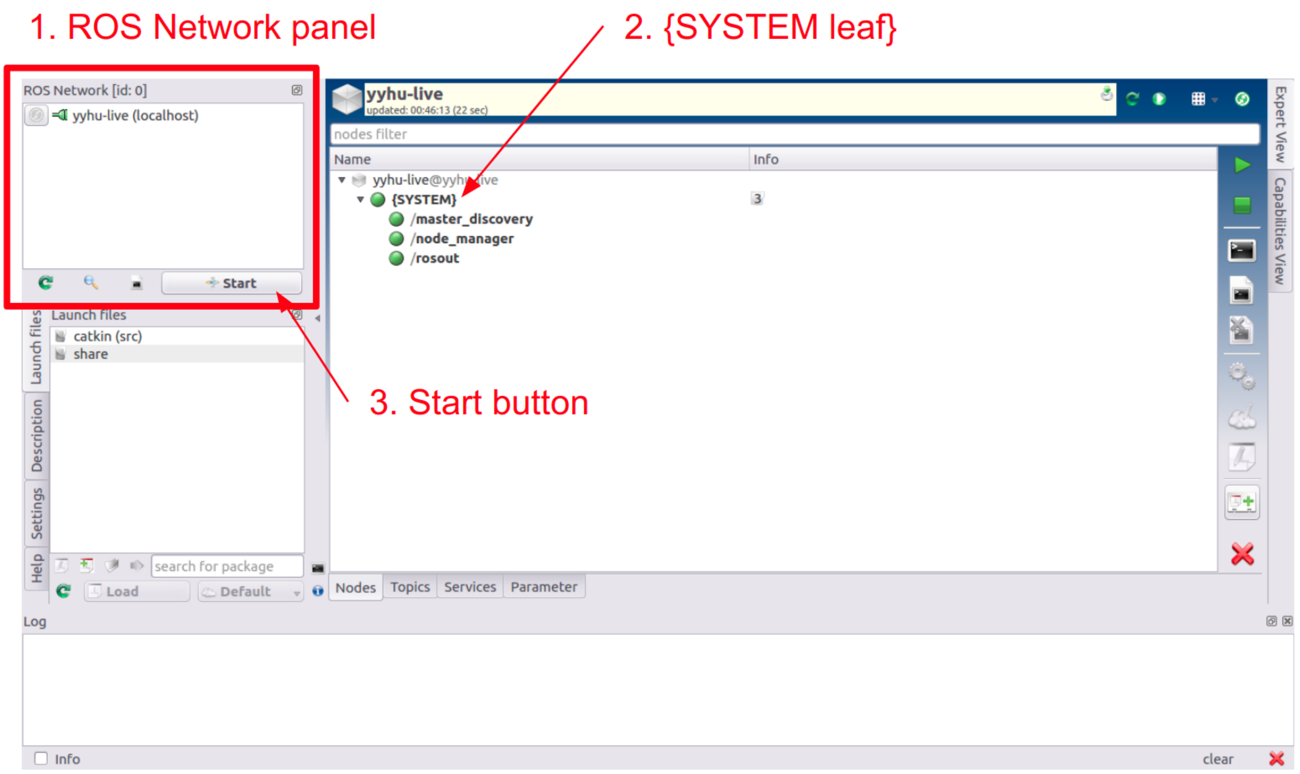


Figure 8 node_manager. ↑

At the moment, the “ROS Network” panel (left-top corner, #1 in figure 8) shows no enabled networks. This is because there are no master_discovery nodes running in the network. Under the “{SYSTEM}” leaf (#2 in figure 8), there are only other two ROS nodes running. We enable a network by clicking the “Start” button (#3 in figure 8) on the “ROS Network” panel. Then we will see the “Start discovery” dialog window, as illustrated in figure 9.

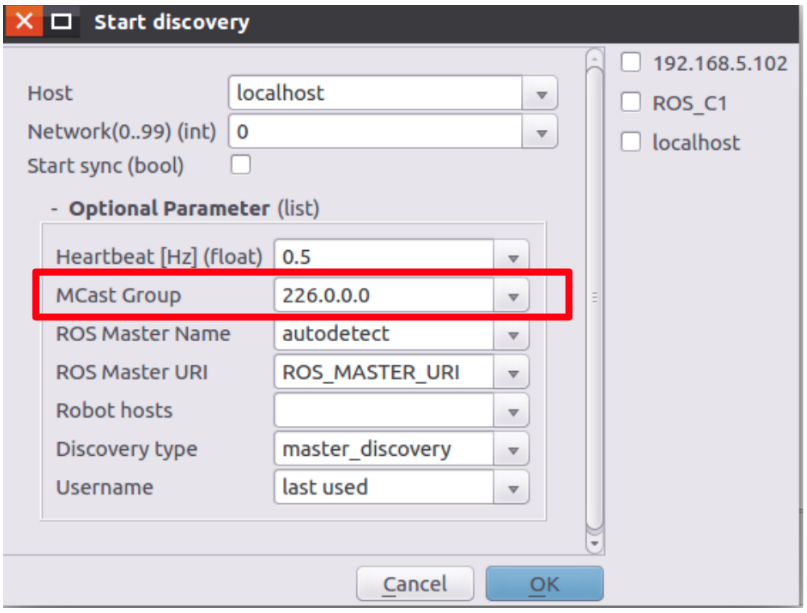


Figure 9 Start discovery dialog window. ↑

Leave everything as their default values except the "MCast Group" then click OK. A new master_discovery node (#1 in figure 10) will be shown under the {SYSTEM} leaf and a newly enabled ROS network, id:0, is shown in the "ROS Network" panel (#2 in figure 10). Figure 10 shows this view.

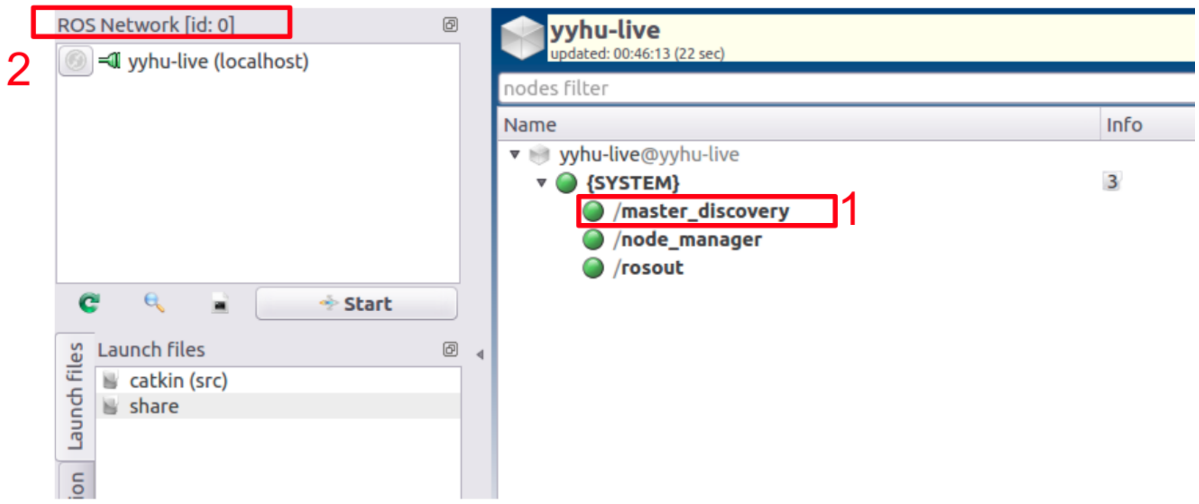


Figure 10 The master_discovery node started. ↑

Now we could use the button shown in figure 11 (#1) to start the master_sync node.

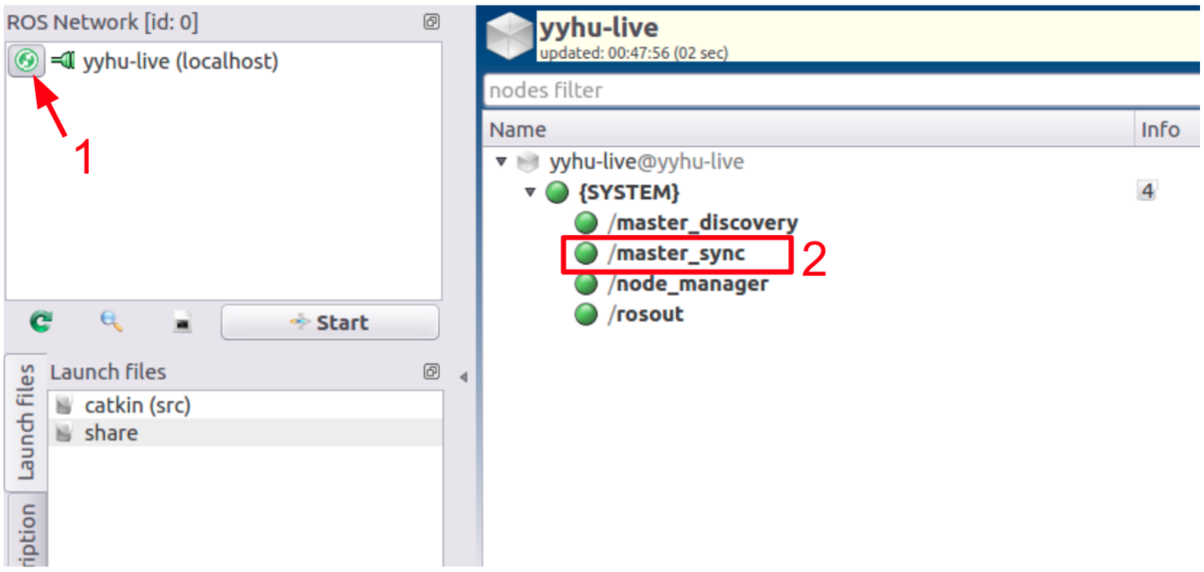


Figure 11 Start master_sync node in the node_manager. ↑

Then this button changes its color and a new master_sync node (#2 in figure 11) is launched.

To let the ROS network discover new client, we have to manually launch the master_discovery node on the client which is C1 for our example. On C1, launch ane new master_discovery node within "screen" and with a different node name. As shown in figure 12, we will see C1's information.

```
screen -S _master_discovery_ai -dm rosrun master_discovery_fkie master_
```

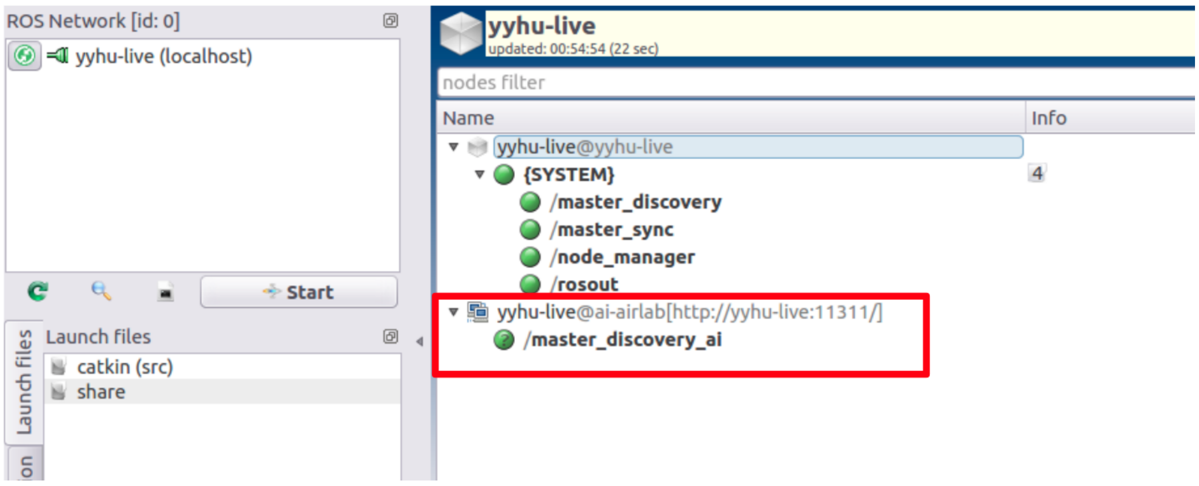


Figure 12 master_discovery node started on the remote client. ↑

If the master_discovery node launched successfully, we could see its information in node_manager.

Now we could launch our sample node on C1 by

```
screen -S _simple_pub_launch -dm roslaunch test_pub simple_pub.launch
```

After launching, node_manager on C0 will show its information, as illustrated in figure 13 (#1).

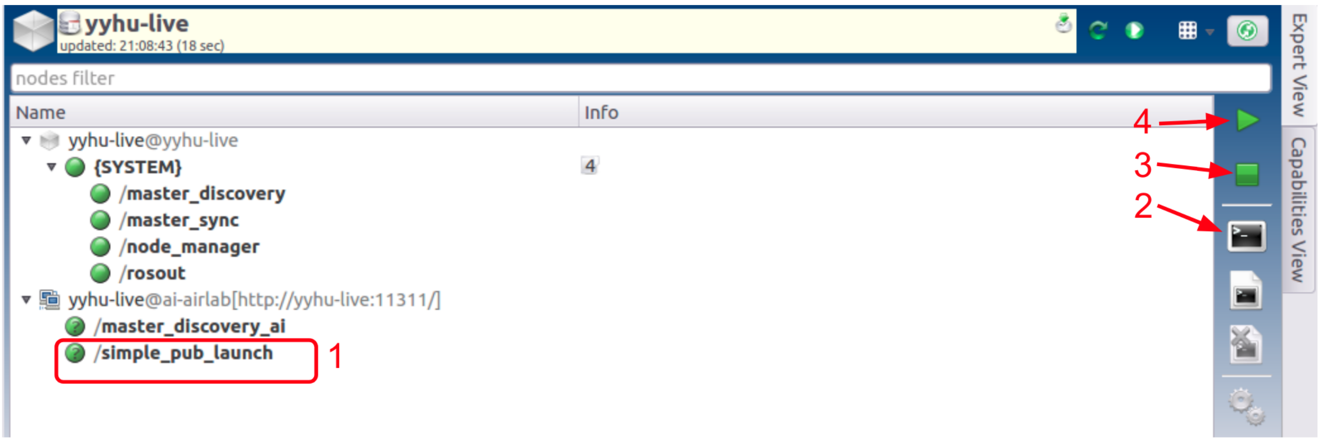


Figure 13 /simple_pub_launch node launched on remote computer. ↑

We could use the tool (#2 in figure 13) provided by node_manager to open an SSH session on C0 to get access to the "screen" which is running on C1. Select any node under "yyhu-live@ai-airlab[http://yyhu-live:11311/]", click the button (#2 in figure 13) or use the shortcut "F3" to start an SSH session to the "screen" containing that node. A dialog window, figure 14, will pop up to request the username and password for the SSH session. The user may have to input his/her password a second time on the opened SSH session.

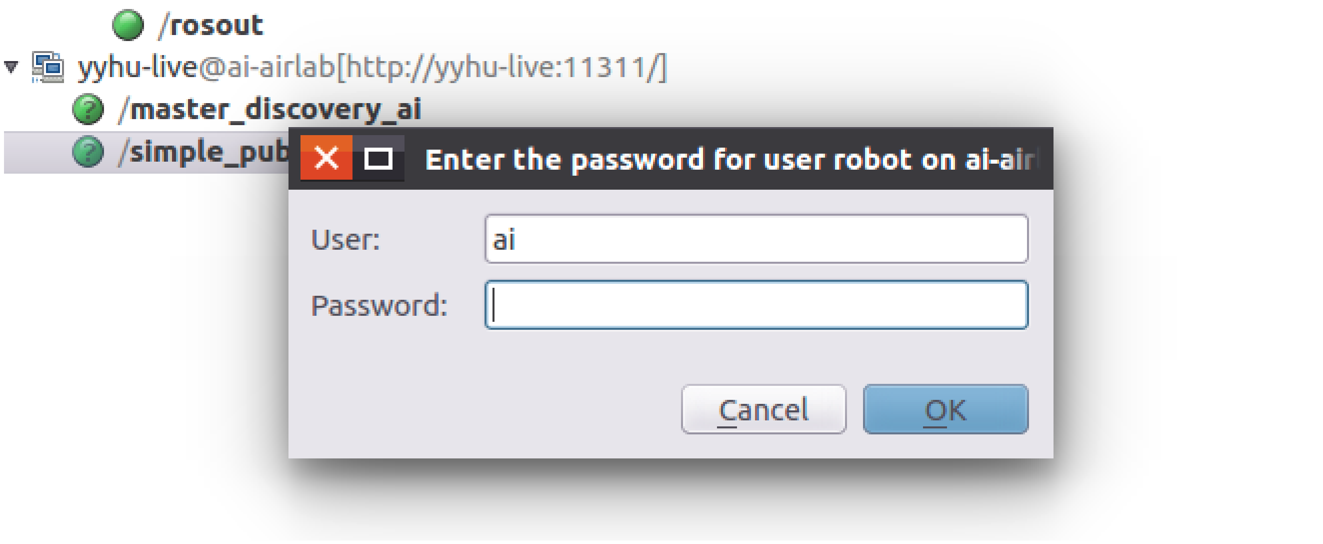

/rosout
yyhu-live@ai-airlab[http://yyhu-live:11311/]
/master_discovery_ai
/simple_pub
Enter the password for user robot on ai-air
User:
ai
Password:
Cancel
OK

Figure 14 SSH login dialog. ↑

Use "Ctrl+a, d" to detach and close this window.

On C1, the user could use

```
screen -ls
```

To checkout the list of "screen"s.

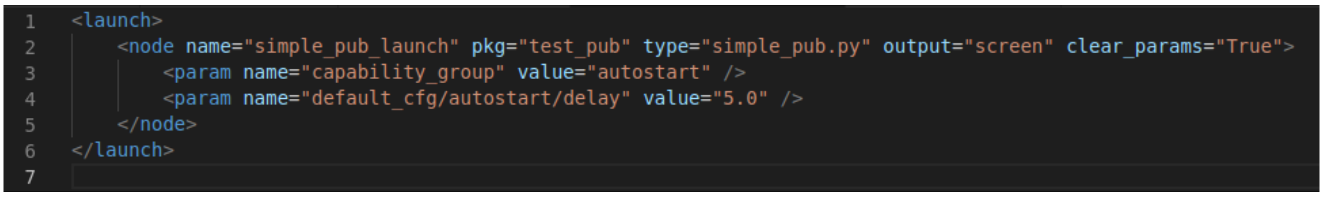
On C0, the user could stop the /simple_pub_launch node by clicking the "stop selected service" button (#3 in figure 13) to the left of the GUI of node_manager. Once clicked, the "screen" process on C1 will be killed and command "rosnode list" will show no sign of /simple_pub_launch.

2.3 default_cfg

For now, the user still has to manually launch a ROS node on C1 (in a "screen") to let the node_manager see and interact with it. In fact, multimaster_fkie provides a method to launch a node in the remote client. This is achieved by the default_cfg node.

default_cfg node expects a launch file. In that launch file, the user list all the nodes that he/she would like to let node_manager on C0 to manage. default_cfg node provides some additional functionalities such as autostart and respawn, delayed start, and conditional start. The user is encouraged to check out the official documentation to learn all the possible functions.

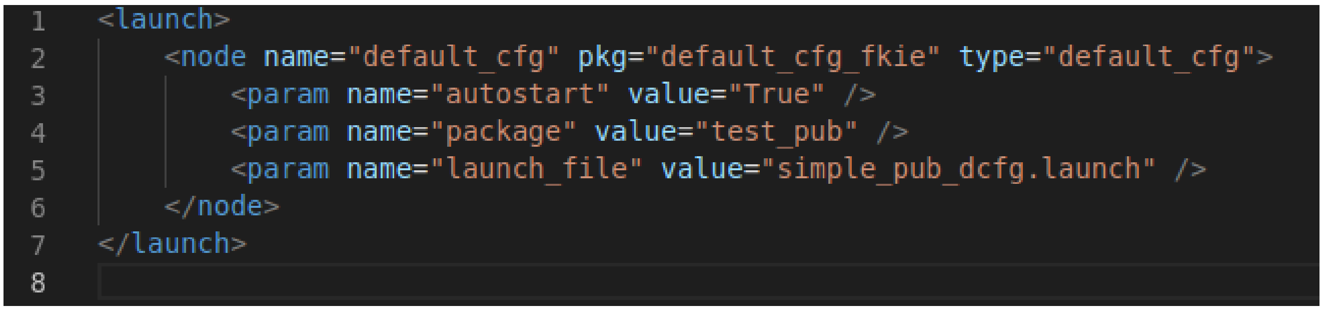
With our test_pub package, we compose a new launch file for default_cfg as shown in figure 15.



```
<launch>
    <node name="simple_pub_launch" pkg="test_pub" type="simple_pub.py" output="screen" clear_params="True">
        <param name="capability_group" value="autostart" />
        <param name="default_cfg/autostart/delay" value="5.0" />
    </node>
</launch>
```

Figure 15 The test_pub launch file for default_cfg node. ↑

Note that we configured a delayed autostart for the simple_pub_launch node (the ROS node name we configured in this launch file.) Then we prepare another launch file, shown in figure 16, for launching default_cfg itself (The file name is "default_cfg_test.launch").



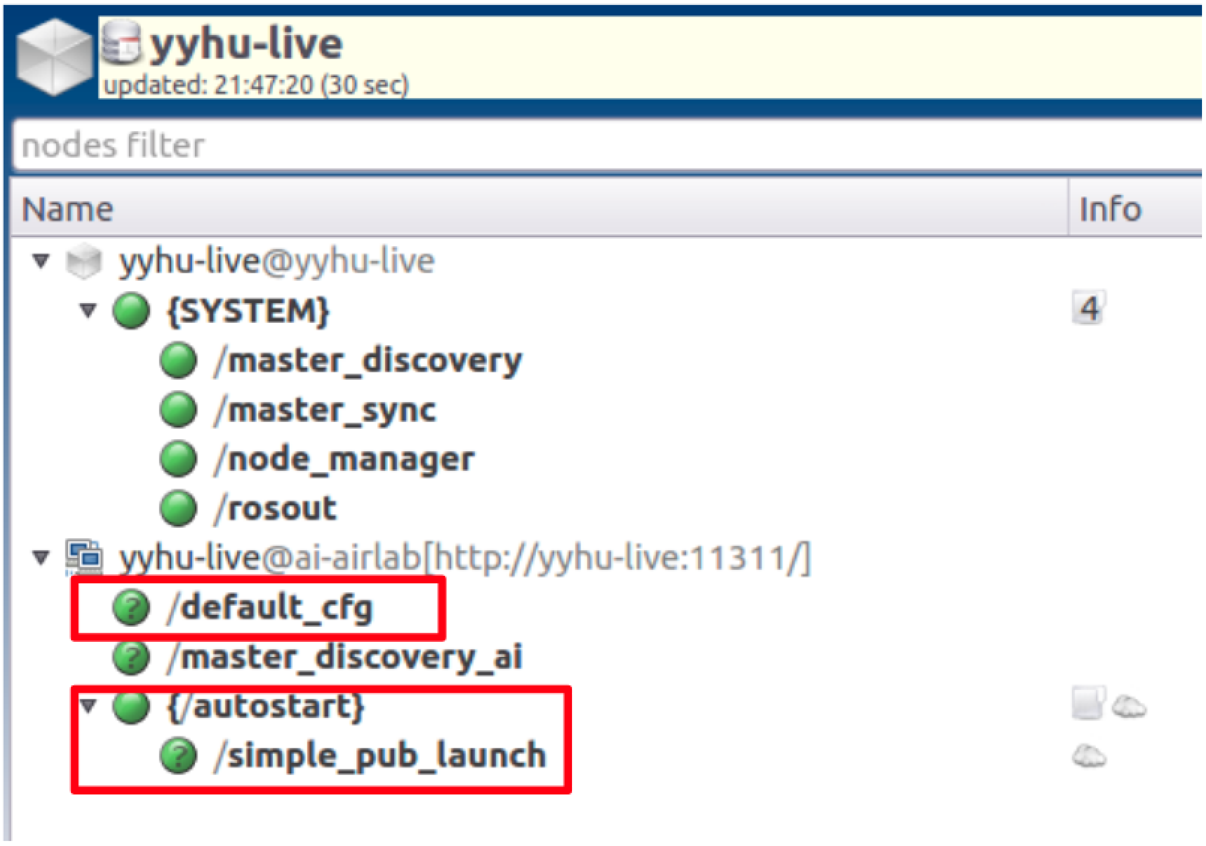
```
<launch>
    <node name="default_cfg" pkg="default_cfg_fkie" type="default_cfg">
        <param name="autostart" value="True" />
        <param name="package" value="test_pub" />
        <param name="launch_file" value="simple_pub_dcfg.launch" />
    </node>
</launch>
```

Figure 16 The launch file to launch default_cfg itself. ↑

In this launch file, we enable the autostart function and tells defualt_cfg the information of the node to launch. Then we could launch default_cfg as usual with a "screen".

```
screen -S _default_cfg -dm roslaunch default_cfg_fkie default_cfg_test.
```

Then as shown in figure 17 on C0, we could see that there are two new nodes get launched.


yyhu-live
updated: 21:47:20 (30 sec)
nodes filter

Name	Info
yyhu-live@yyhu-live	
{SYSTEM}	4
/master_discovery	
/master_sync	
/node_manager	
/rosout	
yyhu-live@ai-airlab[http://yyhu-live:11311/]	
/default_cfg	
/master_discovery_ai	
{/autostart}	
/simple_pub_launch	

Figure 17 defult_cfg launched on remote client. ↑

If we could operate our computer in a prompt fashion (or set a larger delay time for autostarting), we could see that the /simple_pub node gets launched after a requested delay, as configured in the launch file shown in figure 15.

Now, a user could stop or restart a ROS node by clicking the "start selected service" and "stop selected service" buttons (#4 and #3 in figure 13) of node_manager on C0, to control this node remotely.

2.4 Other stuff

To stop the entire ROS network, quit node_manager, and stop roscore, use the red cross button (see figure 18) on the node panel (the larger red cross). Once clicked, the "Close/Stop/Shutdown" dialog will be brought to the front, see figure 19. Choose "stop ROS" to quit the roscore at the same time. Note that, choosing "shutdown host" will turn off the C0 computer.

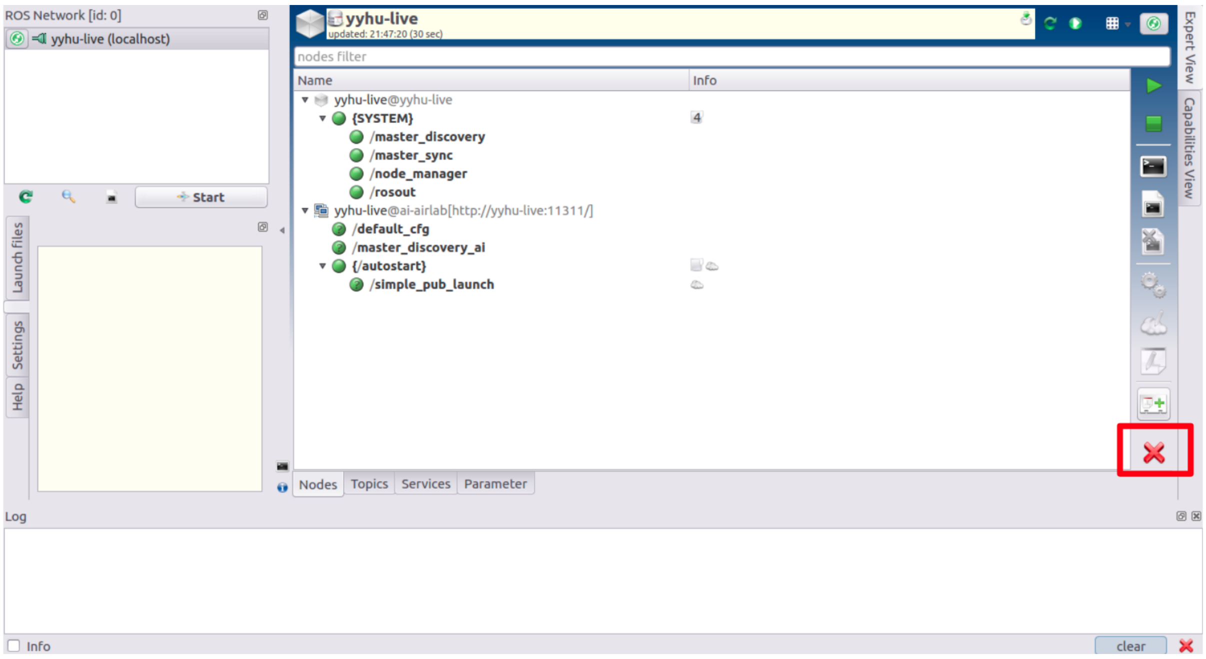


Figure 18 The larger red cross. ↑

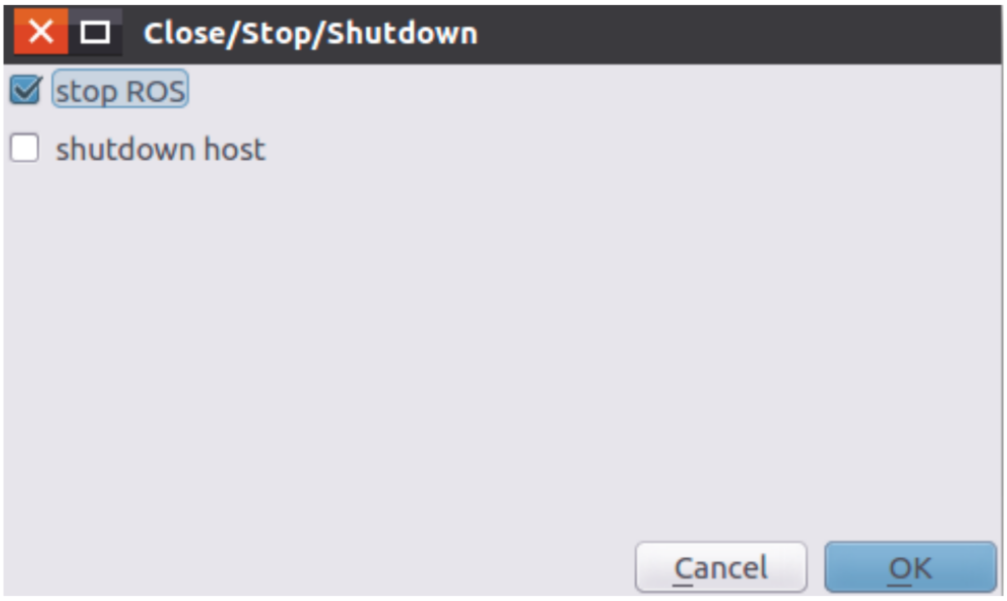


Figure 19 The “Close/Stop/Shutdown” dialog. ↑

Image courtesy: The cover image is copied from the ROS official website.

Yaoyu Hu's personal site

Yaoyu Hu's personal site
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huyaoyu

Here are the life of Yaohu Hu. His world, his happiness and his dreams.