

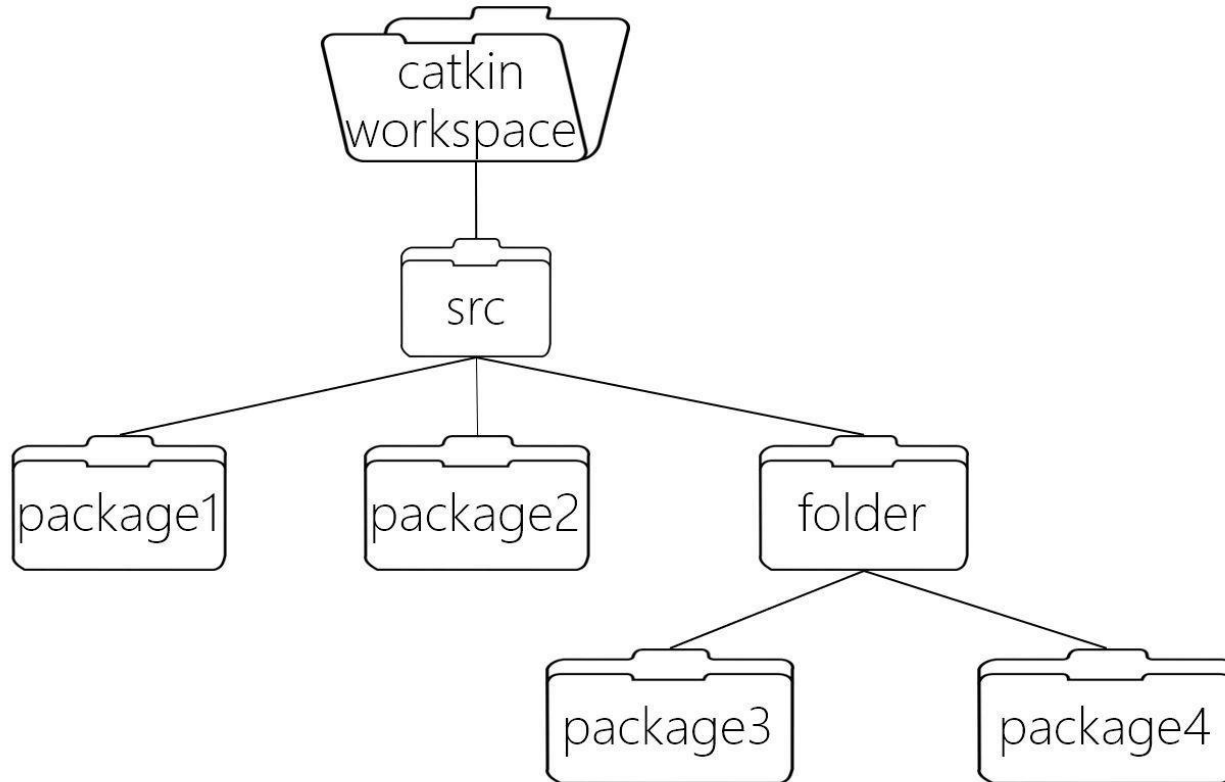
無人載具技術與應用

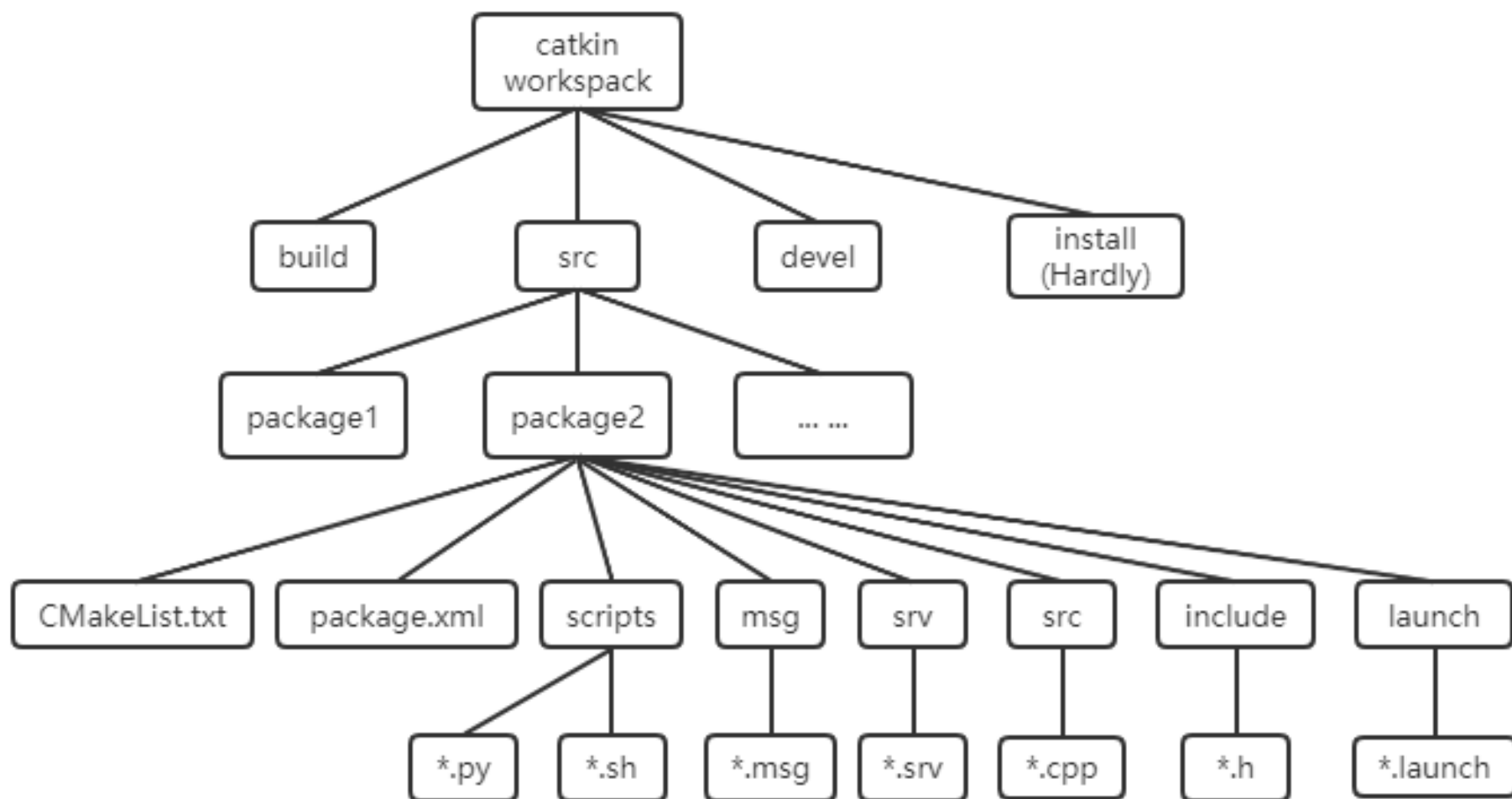
ROS

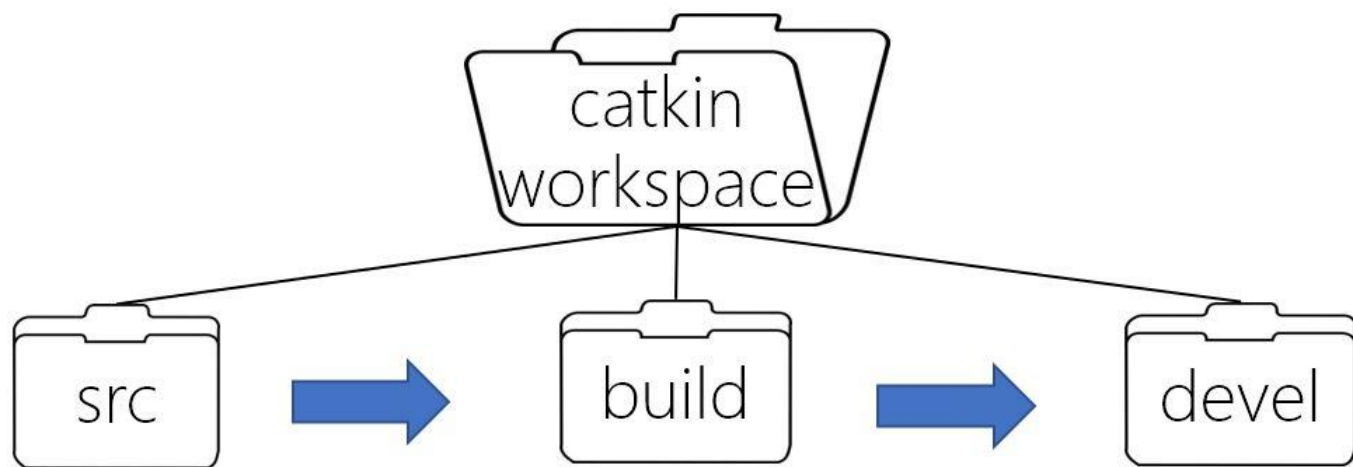
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一般 程式







package源代码包

cmake&catkin缓存和中间文件

目标文件

catkin_ws
(ROS package)

catkin



CMakeLists.txt

cmake



Makefile

make



hello.cpp

gcc/g++



hello.o

gcc/g++



hello

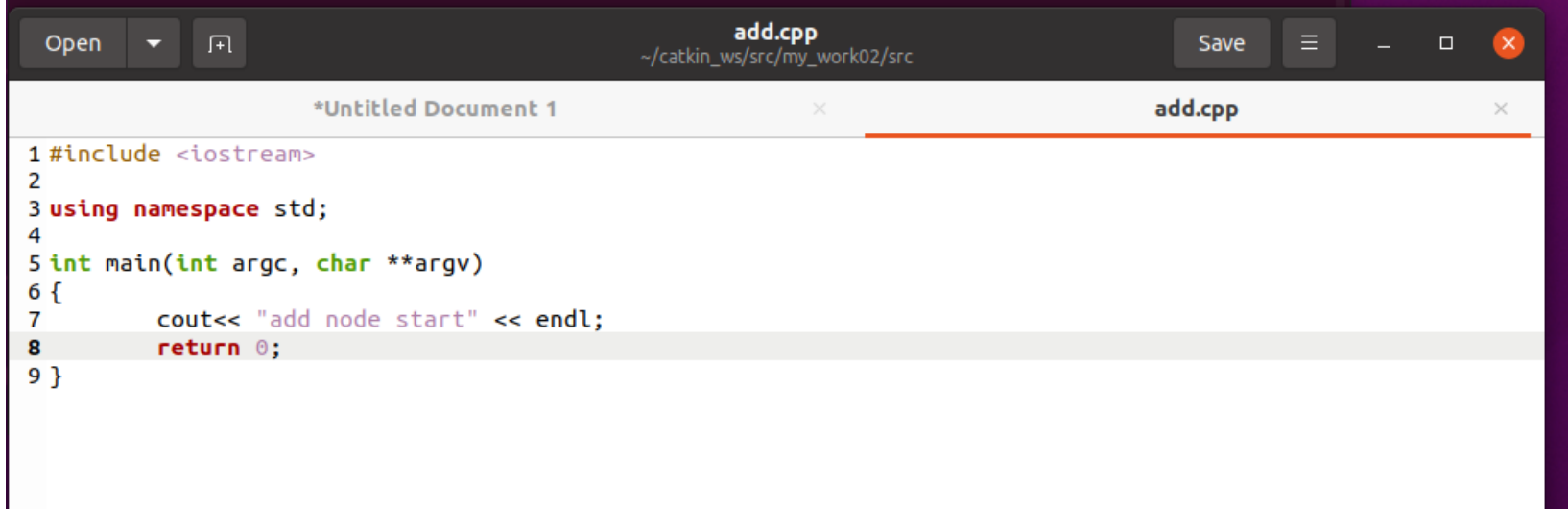
一般CPP程式01

```
user@user-virtual-machine: ~/catkin_ws/src
user@user-virtual-machine:~$ cd catkin_ws/src/
user@user-virtual-machine:~/catkin_ws/src$ catkin_
catkin_create_pkg      catkin_package_version
catkin_find            catkin_prepare_release
catkin_find_pkg        catkin_tag_changelog
catkin_generate_changelog catkin_test_changelog
catkin_init_workspace  catkin_test_results
catkin_make            catkin_topological_order
catkin_make_isolated
user@user-virtual-machine:~/catkin_ws/src$ catkin_create_pkg my_work02 roscpp rospy std_msgs
Created file my_work02/package.xml
Created file my_work02/CMakeLists.txt
Created folder my_work02/include/my_work02
Created folder my_work02/src
Successfully created files in /home/user/catkin_ws/src/my_work02. Please adjust the values in
package.xml.
user@user-virtual-machine:~/catkin_ws/src$ ls
CMakeLists.txt  my_work01  my_work02
user@user-virtual-machine:~/catkin_ws/src$
```

```
cd catkin_ws/src/
catkin_create_pkg my_work02 roscpp rospy std_msgs
ls
```

一般CPP程式02

```
user@user-virtual-machine:~/catkin_ws/src$ cd my_work02/src/  
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$ gedit add.cpp &  
[1] 2278  
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$
```



```
Open  add.cpp  Save  ~/catkin_ws/src/my_work02/src  
*Untitled Document 1  add.cpp  
1 #include <iostream>  
2  
3 using namespace std;  
4  
5 int main(int argc, char **argv)  
6 {  
7     cout<< "add node start" << endl;  
8     return 0;  
9 }
```

```
cd my_work02/src/  
gedit add.cpp &
```


一般C++程式03

```
user@user-virtual-machine:~/catkin_ws/src$ cd my_work02/src/  
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$ gedit add.cpp &  
[1] 2278  
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$
```



```
add.cpp  
~/catkin_ws/src/my_work02/src  
*Untitled Document 1  
add.cpp  
1 #include <iostream>  
2  
3 using namespace std;  
4  
5 int main(int argc, char **argv)  
6 {  
7     cout<< "add node start" << endl;  
8     return 0;  
9 }
```

```
#include <iostream>
```

```
using namespace std;
```

```
int main(int argc, char **argv)
```

```
{
```

```
    cout<< "add node start" << endl;
```

```
    return 0;
```

```
}
```

一般C++程式04

```
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$ g++ -o add add.cpp  
[1]+  Done                  gedit add.cpp  
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$ ls  
add  add.cpp  
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$ ./add  
add node start  
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$
```

g++ -o add add.cpp

編譯程式

ls

./add

執行程式

一般程式增加 ROS功能

一般C++程式→ros node 01

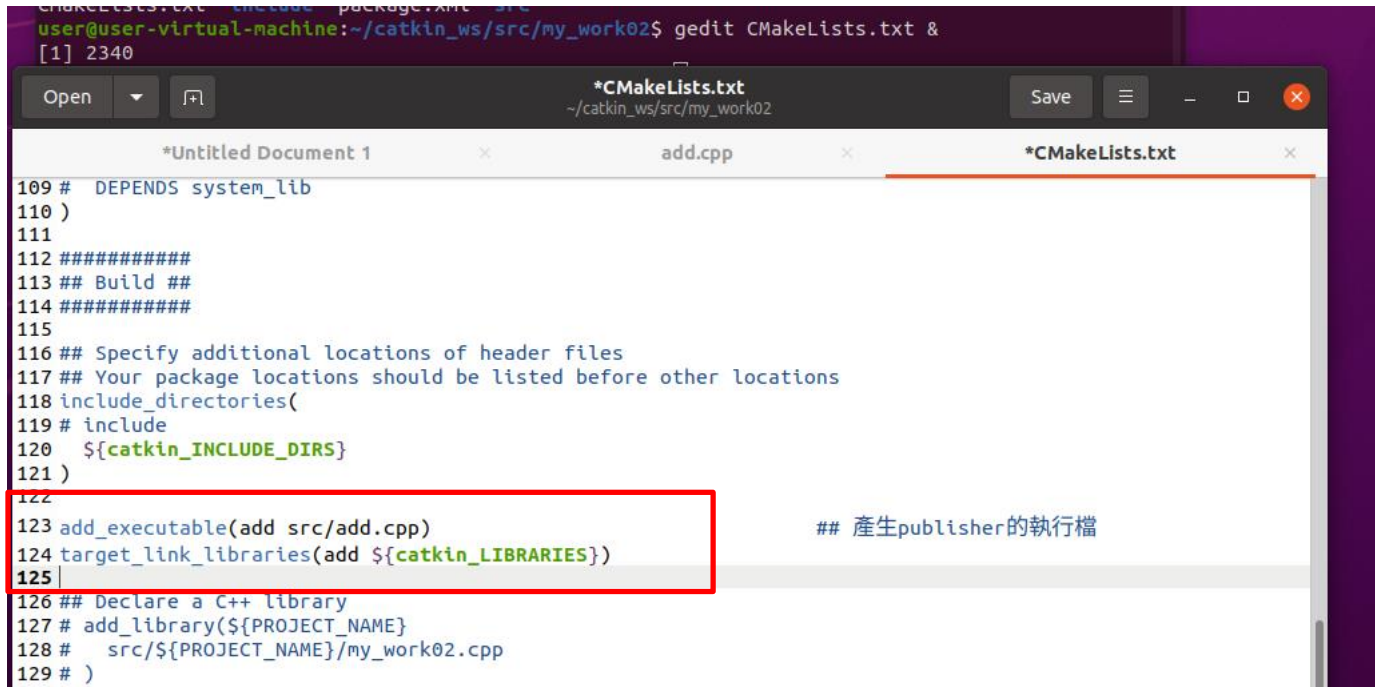
```
user@user-virtual-machine:~/catkin_ws/src/my_work02/src$ gedit add.cpp

add.cpp
~/catkin_ws/src/my_work02/src

*Untitled Document 1
add.cpp

1 #include <iostream>
2 #include "ros/ros.h" // 加入ROS公用程序
3 #include "std_msgs/String.h" // 所要publish的message header, 在此是std_msgs package底下的String.msg
4 #include <sstream>
5
6 using namespace std;
7
8 void cmdCallback(const std_msgs::String::ConstPtr& msg)
9 {
10     ROS_INFO("add heard: [%s]", msg->data.c_str());
11 }
12
13 int main(int argc, char **argv)
14 {
15     ros::init(argc, argv, "adder");
16     ros::NodeHandle n;
17     cout<< "add node start" << endl;
18
19     ros::Subscriber sub = n.subscribe("cmd", 1000, cmdCallback);
20     ros::spin();
21
22     return 0;
23 }
```

一般CPP程式 → ros node 02



The image shows a terminal window at the top with the command `gedit CMakeLists.txt &` and its output `[1] 2340`. Below the terminal is a code editor window titled `*CMakeLists.txt` with the path `~/catkin_ws/src/my_work02`. The editor shows a CMakeLists.txt file with several tabs: `*Untitled Document 1`, `add.cpp`, and `*CMakeLists.txt`. The code in the `*CMakeLists.txt` tab includes comments and CMake commands. Lines 123 and 124 are highlighted with a red box. Line 123 is `add_executable(add src/add.cpp)` and line 124 is `target_link_libraries(add ${catkin_LIBRARIES})`. To the right of these lines is a comment: `## 產生publisher的執行檔`. Other visible code includes `include_directories` and `add_library` commands.

```
109 # DEPENDS system_lib
110 )
111
112 #####
113 ## Build ##
114 #####
115
116 ## Specify additional locations of header files
117 ## Your package locations should be listed before other locations
118 include_directories(
119 # include
120 ${catkin_INCLUDE_DIRS}
121 )
122
123 add_executable(add src/add.cpp)
124 target_link_libraries(add ${catkin_LIBRARIES})
125
126 ## Declare a C++ library
127 # add_library(${PROJECT_NAME}
128 #   src/${PROJECT_NAME}/my_work02.cpp
129 # )
```

```
add_executable(add src/add.cpp)
target_link_libraries(add ${catkin_LIBRARIES})
```

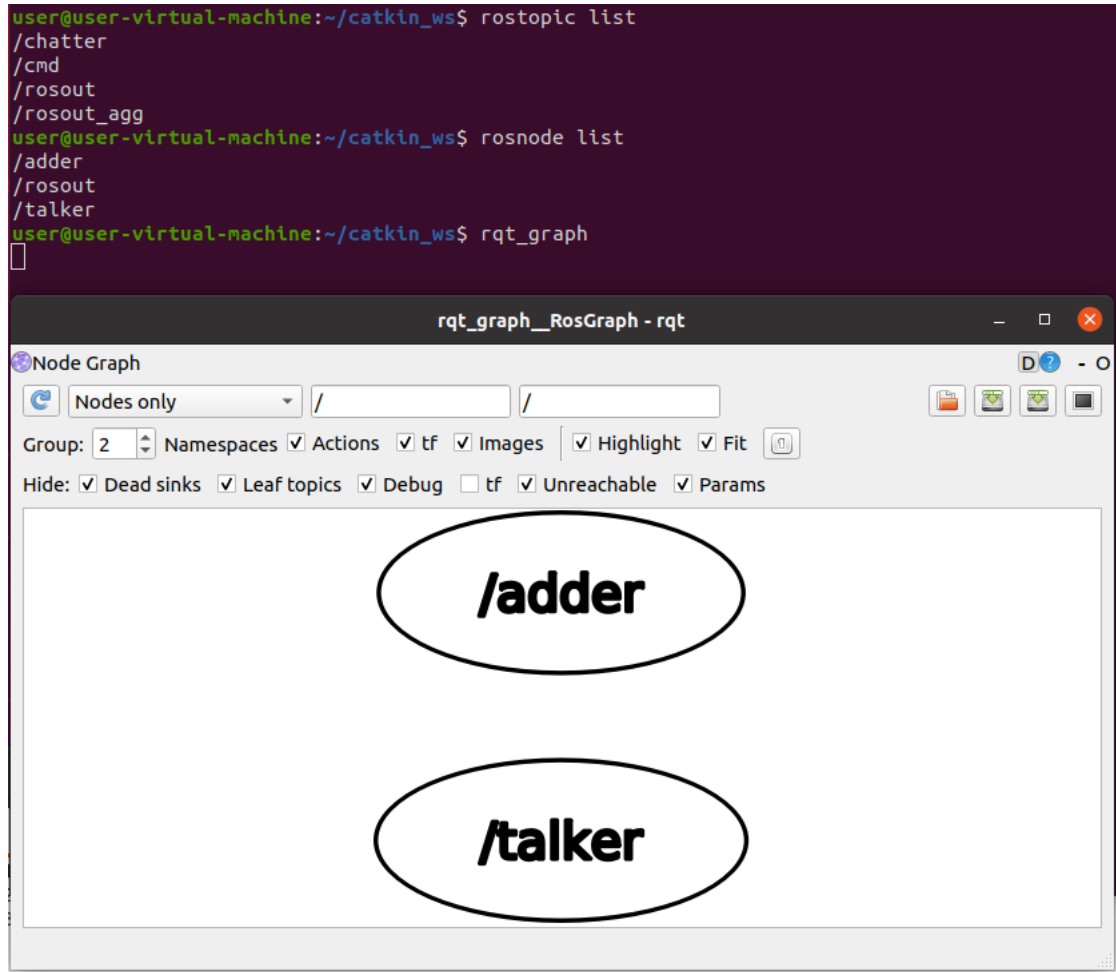
一般CPP程式→ros node 03

```
user@user-virtual-machine:~/catkin_ws/src/my_work02$ cd ../../
[1]+  Done                  gedit CMakeLists.txt  (wd: ~/catkin_ws/src/my_work02)
(wd now: ~/catkin_ws)
user@user-virtual-machine:~/catkin_ws$ catkin_make
Base path: /home/user/catkin_ws
Source space: /home/user/catkin_ws/src
Build space: /home/user/catkin_ws/build
Devel space: /home/user/catkin_ws/devel
Install space: /home/user/catkin_ws/install
####
#### Running command: "cmake /home/user/catkin_ws/src -DCATKIN_DEVEL_PREFIX=/home/user/catkin_ws/devel -DCMAKE_INSTALL_PREFIX=/home/user/catkin_ws/install -G Unix Makefiles" in "/home/user/catkin_ws/build"
####
-- Using CATKIN_DEVEL_PREFIX: /home/user/catkin_ws/devel
-- Using CMAKE_PREFIX_PATH: /home/user/catkin_ws/devel;/opt/ros/noetic
-- This workspace overlays: /home/user/catkin_ws/devel;/opt/ros/noetic
-- Found PythonInterp: /usr/bin/python3 (found suitable version "3.8.10", minimum required is "3")
```

```
-- *** processing catkin package: 'my_work01'
-- ==> add_subdirectory(my_work01)
-- *** processing catkin package: 'my_work02'
-- ==> add_subdirectory(my_work02)
-- Configuring done
-- Generating done
-- Build files have been written to: /home/user/catkin_ws/build
####
#### Running command: "make -j4 -l4" in "/home/user/catkin_ws/build"
####
[100%] Built target listener
[100%] Built target talk
user@user-virtual-machine:~/catkin_ws$
```

cd ../../
catkin_make

一般CPP程式→ros node 04



roscore

roslaunch my_work02 add

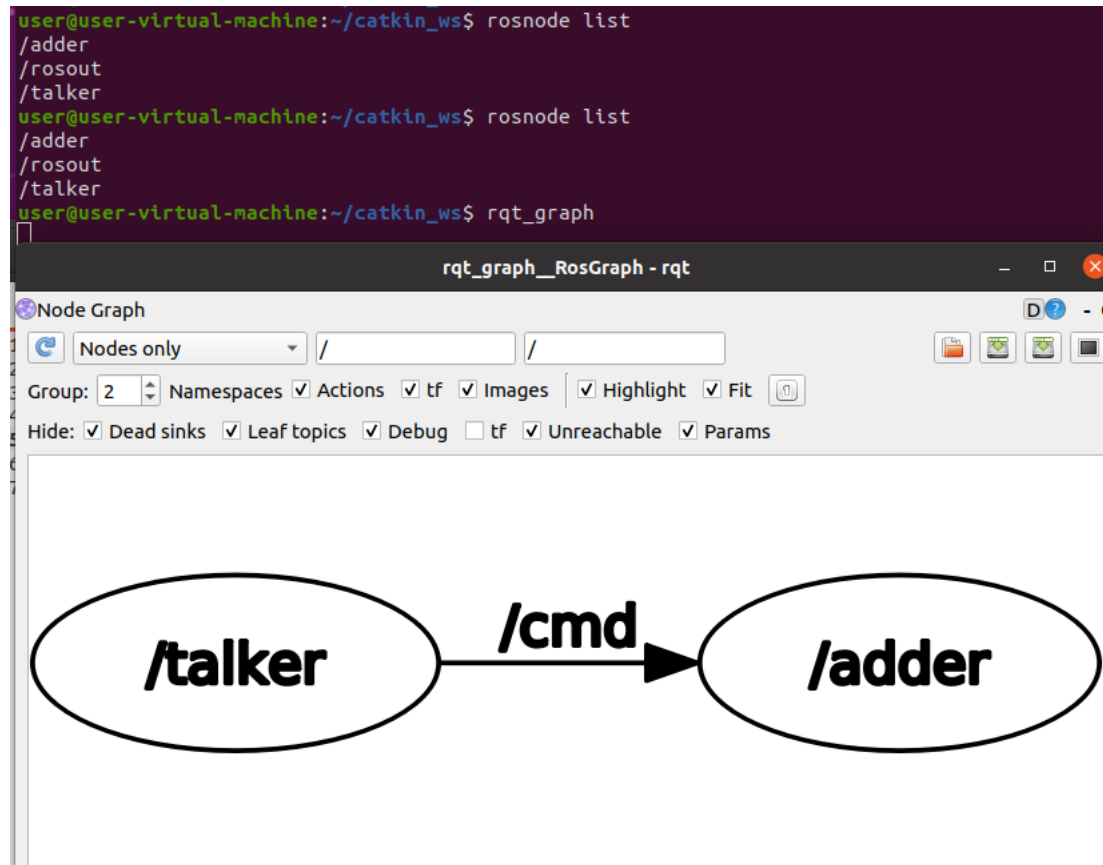
roslaunch my_work01 talk

rostopic list

rosnode list

rqt_graph

一般CPP程式→ros node 05



roscore

roslaunch my_work02 add

roslaunch my_work01 talk **/chatter:=/cmd**

rostopic list

roscore list

rqt_graph

The screenshot shows a web browser displaying a GitHub repository page for 'Waywrong / ros_course'. The repository is marked as 'Public'. The navigation bar includes links for 'Code', 'Issues', 'Pull requests', 'Actions', 'Projects', and 'Wiki'. Below the navigation bar, there is a dropdown menu for branches, currently showing 'main'. The file path 'ros_course / my_work02 / src / add.cpp' is displayed. Below the file path, there is a section for the file's history, showing 'Waywrong my_work02' and a 'History' link. Below the history section, there is a section for contributors, showing '1 contributor'. The main content area displays the code for 'add.cpp', which is 23 lines long (18 sloc) and 551 Bytes. The code includes headers for iostream, ros/ros.h, std_msgs/String.h, and sstream, and defines a callback function cmdCallback and a main function.

每次專案有改變時 皆須執行以下(只改設定檔 則不須)

```
cd ~/catkin_ws
```

```
catkin_make
```

```
peter@peter-lenovo-g50-80:~/catkin_ws/src$ cd ~/catkin_ws/  
peter@peter-lenovo-g50-80:~/catkin_ws$ catkin_make
```

```
peter@peter-lenovo-g50-80:~/catkin_ws$ catkin_make  
Base path: /home/peter/catkin_ws  
Source space: /home/peter/catkin_ws/src  
Build space: /home/peter/catkin_ws/build  
Devel space: /home/peter/catkin_ws/devel  
Install space: /home/peter/catkin_ws/install  
####  
#### Running command: "make cmake_check_build_system" in "/home/peter/catkin_ws/  
build"  
####  
####  
#### Running command: "make -j4 -l4" in "/home/peter/catkin_ws/build"  
####  
Scanning dependencies of target test_talk  
[ 33%] Built target listener  
[ 66%] Built target talk  
[ 83%] Building CXX object my_work01/CMakeFiles/test_talk.dir/src/test.cpp.o  
[100%] Linking CXX executable /home/peter/catkin_ws/devel/lib/my_work01/test_tal  
k  
[100%] Built target test_talk  
peter@peter-lenovo-g50-80:~/catkin_ws$
```

多主機通訊

Ifconfig 取得IP資訊

```
peter@peter-lenovo-g50-80: ~  
peter@peter-lenovo-g50-80:~$ ifconfig  
docker0    Link encap:Ethernet  HWaddr 02:42:cc:88:43:ed  
            inet addr:172.17.0.1  Bcast:172.17.255.255  Mask:255.255.0.0  
            UP BROADCAST MULTICAST  MTU:1500  Metric:1  
            RX packets:0 errors:0 dropped:0 overruns:0 frame:0  
            TX packets:0 errors:0 dropped:0 overruns:0 carrier:0  
            collisions:0 txqueuelen:0  
            RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)  
  
enp2s0     Link encap:Ethernet  HWaddr 68:f7:28:a1:fd:93  
            UP BROADCAST MULTICAST  MTU:1500  Metric:1  
            RX packets:0 errors:0 dropped:0 overruns:0 frame:0  
            TX packets:0 errors:0 dropped:0 overruns:0 carrier:0  
            collisions:0 txqueuelen:1000  
            RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)  
  
lo         Link encap:Local Loopback  
            inet addr:127.0.0.1  Mask:255.0.0.0  
            inet6 addr: ::1/128 Scope:Host  
            UP LOOPBACK RUNNING  MTU:65536  Metric:1  
            RX packets:37720055 errors:0 dropped:0 overruns:0 frame:0  
            TX packets:37720055 errors:0 dropped:0 overruns:0 carrier:0  
            collisions:0 txqueuelen:1000  
            RX bytes:2810156684 (2.8 GB)  TX bytes:2810156684 (2.8 GB)  
  
wlp3s0     Link encap:Ethernet  HWaddr 38:b1:db:e0:b1:a7  
            inet addr:192.168.0.141  Bcast:192.168.0.255  Mask:255.255.255.0  
            inet6 addr: fe80::40ca:7198:e52f:b10e/64 Scope:Link  
            UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1  
            RX packets:21570656 errors:0 dropped:0 overruns:0 frame:8380155  
            TX packets:7623866 errors:214 dropped:0 overruns:0 carrier:0  
            collisions:0 txqueuelen:1000  
            RX bytes:1941987413 (1.9 GB)  TX bytes:1249664612 (1.2 GB)  
            Interrupt:19
```

ping 啟動roscore的電腦IP，確認雙方通訊正常

```
peter@peter-lenovo-g50-80:~$ ping 192.168.0.1  
PING 192.168.0.1 (192.168.0.1) 56(84) bytes of data: wlp3s0  
64 bytes from 192.168.0.1: icmp_seq=1 ttl=64 time=4.30 ms  
64 bytes from 192.168.0.1: icmp_seq=2 ttl=64 time=36.7 ms  
64 bytes from 192.168.0.1: icmp_seq=3 ttl=64 time=59.3 ms  
64 bytes from 192.168.0.1: icmp_seq=4 ttl=64 time=2.46 ms
```

export ROS_MASTER_URI="http://192.168.0.1:11311" 開啟roscore電腦IP
export ROS_IP=192.168.0.141 所在電腦IP

開啟roscore電腦(192.168.0.1) e.g. 機器人

```
peter@peter-lenovo-g50-80: ~  
peter@peter-lenovo-g50-80:~$ export ROS_MASTER_URI="http://192.168.0.1:11311"  
peter@peter-lenovo-g50-80:~$ export ROS_IP=192.168.0.1  
peter@peter-lenovo-g50-80:~$ roscore
```

所在電腦(192.168.0.141) e.g. 筆電

```
peter@peter-lenovo-g50-80: ~  
peter@peter-lenovo-g50-80:~$ export ROS_MASTER_URI="http://192.168.0.1:11311"  
peter@peter-lenovo-g50-80:~$ export ROS_IP=192.168.0.141  
peter@peter-lenovo-g50-80:~$ rostopic list  
  
peter@peter-lenovo-g50-80:~$ rostopic list  
/rosout  
/rosout_agg  
peter@peter-lenovo-g50-80:~$
```

export ROS_MASTER_URI="http://192.168.50.68:11311"
export ROS_IP=192.168.50.XX

rostopic list

ROS多機運作

- 1. 兩人一組
- 2. 其中一人先執行roscore
- 3. 一台機器執行 talk
 一台機器執行listener
- 4. 兩人角色對調

```
peter@peter-VirtualBox: ~/catkin_ws
peter@peter-VirtualBox:~/catkin_ws$ roscore
```

source ~/catkin_ws/devel/setup.bash

```
peter@peter-VirtualBox: ~/catkin_ws
peter@peter-VirtualBox:~/catkin_ws$ rosrun my_work01 talk
```

```
peter@peter-VirtualBox: ~/catkin_ws
peter@peter-VirtualBox:~/catkin_ws$ rosrun my_work01 listener
```

作業2

- 建立專案(my_hw02)，並上傳相關檔案
- 參考3/28上課內容，"ROS-Class-5.pdf"
- 模仿 my_work01/src/talk.cpp，寫一個會發布訊息(rostopic)的專案(my_hw02)
- 計分部分包含
 - 1. 修改rostopic 名稱
 - 2. 修改roscpp 名稱
 - 3. 接收訊息的listener, 可用my_work01/src/listener.cpp(如自行修改另有計分)
 - 4. 紀錄實驗過程於word檔，紀錄所下的命令與回應，可多利用截圖(圖文並茂加分)
 - roscpp list
 - rostopic list
 - rqt_graph
- 上傳作業包含 (4/11 前上傳):
- 1. CMakeLists.txt
- 2. package.xml
- 3. XXX.launch (檔名自訂)
- 4. 修改過的cpp檔
- 5. 實驗紀錄word檔