

# ROS Bootcamp - Day 2

## Introduction To ROS1

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# Overview

- ROS package structure
- Integration and programming
- ROS subscribers and publishers
- ROS parameter server
- RViz visualization
- **Activity:** IMU Visualization with ESP32

# ROS Package Structure

- ROS software organized into packages
- Packages contain: source code, launch files, configuration files, message definitions, data, and documentation
- Packages declare dependencies on other packages
- Use `catkin_create_pkg` to create a new package



# Package Directories and Files

- `config`: Parameter files (YAML)
- `include/package_name`: C++ include headers
- `launch`: \*.launch files
- `src`: Source files (C++, etc)
- `scripts`: Script file (Python, etc)
- `test`: Unit/ROS tests
- `package_name_msgs`: Message, Service, and Action definitions
- `CMakeLists.txt`: Cmake build file
- `package.xml`: Package information

# Package.xml

- **package.xml**: Defines package properties (name, version, authors, dependencies, etc.)

```
<?xml version="1.0"?>
<package format="2">
  <name>ros_package_template </name>
  <version>0.1.0</version>
  <description>A ROS package that... </description>
  <maintainer email="youremailt@ethz.ch" >You</maintainer>
  <license>BSD</license>
  <url type="website">https://github.com/leggedrobotics/ros...</url>

  <buildtool_depend >catkin</buildtool_depend >

  <depend>roscpp</depend>
  <depend>std_msgs</depend>

  <build_depend>message_generation </build_depend>
</package>
```

# CMakeLists.txt

- **CMakeLists.txt**: Input to the CMake build system (required CMake version, package name, configure C++ standard and compile features, find other packages needed for build, message/service/action generators, libraries/executables to build, tests, and install rules)

```
cmake_minimum_required (VERSION 3.10.2 )
project(ros_package_template )

## Use C++14, or 11...
set(CMAKE_CXX_STANDARD 14 )
set(CMAKE_CXX_STANDARD_REQUIRED TRUE )

## Find catkin macros and libraries
find_package (catkin REQUIRED
              COMPONENTS
                roscpp
                sensor_msgs
)
...
```

# Object Oriented Programming

- OOP is based on "objects" with data (attributes) and code (methods).
- Key OOP principles: encapsulation, inheritance, polymorphism.
- In ROS, nodes often use OOP for structure and modularity.
- ROS allows binding subscribers to class methods:  

```
subscriber_ = nodeHandle_.subscribe(topic,  
queue_size, &ClassName::methodName, this);
```
- Algorithmic code can be encapsulated in a ROS-independent library for reuse.

# ROS C++ Library (roscpp)

- roscpp provides a C++ API for ROS, enabling communication between nodes.
- roscpp handles topics, services, parameters, and transforms.
- To use roscpp, include the header: `#include <ros/ros.h>`
- Declare roscpp as a dependency in CMakeLists.txt and package.xml when building your package.



# Initializing and Spinning

- Initialize ROS system with `ros::init(argc, argv, "node_name");`
- Create a node handle to interact with ROS
- Start a loop with `ros::spin()` or `ros::spinOnce()` to process incoming messages
- Use `ros::Rate loop_rate(rate);` to set the loop rate in Hz

```
#include "ros/ros.h"
#include "std_msgs/String.h"

void chatterCallback(const std_msgs::
    String::ConstPtr& msg){
    ROS_INFO("I heard: [%s]", msg->data.
        c_str());
}

int main(int argc, char **argv){
    ros::init(argc, argv, "listener");
    ros::NodeHandle n;

    ros::Subscriber sub = n.subscribe("
        chatter", 1000, chatterCallback);

    ros::spin();
    return 0;
}
```

# Node Handles

- Main access point to communicate with the ROS system
- Four main types of node handles:
  - 1 Default (public) node handle: `nh_ = ros::NodeHandle();`
  - 2 Private node handle:  
`nh_private_ = ros::NodeHandle("~");`
  - 3 Namespaced node handle:  
`nh_eth_ = ros::NodeHandle("eth");`
  - 4 Global node handle:  
`nh_global_ = ros::NodeHandle("/");`

More info: [wiki.ros.org/roscpp/Overview/NodeHandles](http://wiki.ros.org/roscpp/Overview/NodeHandles)

# Logging

- Mechanism for logging human-readable text from nodes in the console and to log files
- Instead of `std::cout`, use e.g. `ROS_INFO`
- Automatic logging to console, log file, and `/rosout` topic
- Different severity levels (INFO, WARN, etc.)
- Supports both printf- and stream-style formatting
  - `ROS_INFO("Result: %d", result); // printf`
  - `ROS_INFO_STREAM("Result: " << result);`
- Further features such as conditional, throttled, delayed logging etc.

# ROS Subscribers: Overview

- Subscribers receive messages from publishers on a specific topic
- Callback function is called when a message is received, taking the message content as an argument
- Subscribe to a topic using the `subscribe()` method of the node handle
- Keep the subscriber object until you want to unsubscribe
- Use `ros::spin()` to process callbacks; it won't return until the node is shut down

# ROS Subscribers: Code Example

```
#include "ros/ros.h"
#include "std_msgs/String.h"

// Callback function to handle incoming messages
void chatterCallback(const std_msgs::String::ConstPtr& msg)
{
    ROS_INFO("I heard: [%s]", msg->data.c_str());
}

int main(int argc, char **argv)
{
    ros::init(argc, argv, "listener"); // Initialize ROS system
    ros::NodeHandle n; // Main access point to communications with the ROS system

    // Subscribe to the "chatter" topic. Messages are passed to the chatterCallback
    // function
    ros::Subscriber sub = n.subscribe("chatter", 1000, chatterCallback);

    ros::spin(); // Enter a loop, pumping callbacks

    return 0;
}
```

# ROS Publishers: Overview

- Publishers send messages to subscribers on a specific topic
- Create a publisher using the `advertise()` method of the node handle
- Create the message content
- Publish the message using `publisher.publish(message);`

# Publisher: Code Example

```
#include "ros/ros.h"
#include "std_msgs/String.h"
#include <sstream>

int main(int argc, char **argv){
    ros::init(argc, argv, "talker"); // Initialize ROS system
    ros::NodeHandle n; // Main access point to communications with the ROS system
    // Advertise will be publishing messages on the "chatter" topic to the master
    ros::Publisher chatter_pub = n.advertise<std_msgs::String>("chatter", 1000);
    ros::Rate loop_rate(10); // Set loop rate

    int count = 0; // Message count
    while (ros::ok()){
        std_msgs::String msg;
        std::stringstream ss;
        ss << "hello world " << count;
        msg.data = ss.str();

        chatter_pub.publish(msg); // Publish the message

        ros::spinOnce();
        loop_rate.sleep();
        ++count;
    }
    return 0;
}
```

# ROS Parameter Server

- Nodes use the parameter server to store and retrieve parameters at runtime
- Best used for static data such as configuration parameters
- Parameters can be defined in launch files or separate YAML files
- List all parameters with `> rosparam list`
- Get the value of a parameter with  
`> rosparam get parameter_name`
- Set the value of a parameter with  
`> rosparam set parameter_name value`

More info: [wiki.ros.org/rosparam](http://wiki.ros.org/rosparam)



# Parameters

- Get a parameter in C++ with  
`nodeHandle.getParam(parameter_name, variable)`
- Method returns true if parameter was found, false otherwise
- Global and relative parameter access
- For parameters, typically use the private node handle  
`ros::NodeHandle("~")`

More info: [wiki.ros.org/roscpp/Overview/Parameter](http://wiki.ros.org/roscpp/Overview/Parameter)

- 3D visualization tool for ROS
- Subscribes to topics and visualizes the message contents
- Different camera views (orthographic, top-down, etc.)
- Interactive tools to publish user information
- Save and load setup as RViz configuration
- Extensible with plugins

Run RViz with `> rviz`

# Activity

Find Today's activity sheet at: \docs\lec2  
[https://github.com/UTSARobotics/ros1\\_bootcamp](https://github.com/UTSARobotics/ros1_bootcamp)