Introduction to ROS

COMP3431

Robot Software Architectures
Robot Software Architecture

• A robot’s software has to control a lot of things:
  • 2D/3D Cameras, LIDAR, Microphones, etc
  • Drive motors, Arm motors
  • Vision, Mapping, Navigation
  • Task Planning, Motion Planning
  • Speech and Natural Language Processing
  • ....
Robot Software Architecture

• Component-based software design put each function in its own module
• Need a communication mechanism between components
ROS (Robot Operating System)

- Open-source
- NOT an operating system:
  - Peer-to-peer comms for distributed processes (*nodes*).
  - Library of drivers, filters (e.g., mapping), behaviours (e.g., navigation)
- Not real-time
- OS agnostic (in theory, but only really works on Ubuntu)
- Language agnostic:
  - APIs for Python and C++ and other languages
ROS Basics

- ROS Nodes - registration at process startup
- Two models of comms between nodes:
  - ROS Topics: Publisher-subscriber (many-to-many).

*Commonly: one publisher and many subscribers*
ROS Basics

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  - ROS Services: remote procedure call (one-to-one).
ROS Basics

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- Two models of comms between nodes:
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  - ROS Services: remote procedure call (one-to-one)
- ROS ActionLib
  - Services with incremental feedback
  - built using ROS topics
Messages

- Topics and services use a well-defined message format:
  - Primitive types (e.g., int8, bool, string, etc).
  - User-defined types (e.g., geometry_msgs/Point, sensor_msgs/LaserScan).
  - ROS takes care of generating language bindings (e.g., C++, Python).

```
geometry_msgs/Point
float64 x
float64 y
float64 z
```
Topic Setup

- TCP/IP model - nodes can run on same or different computers.
- ROS *master* provides directory services.
- Scenario: *laser* node publishes and *mapping* node subscribes.
Topic Setup

- TCP/IP model - nodes can run on same or different computers
- ROS master provides directory services
- Scenario: `laser` node publishes and `mapping` node subscribes

Laser node registers with master that it is publishing laser scans on a topic (with some name).
Topic Setup

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Mapping node registers with master that it is subscribing to the topic name.
Topic Setup

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Master tells mapping node that the laser node is publishing the topic.
Topic Setup

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Mapping node initiates direct connection with laser node.
Topic Setup

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Laser node publishes and mapping node receives laser scan messages.
Topic Setup

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- ROS *master* provides directory services.
- Scenario: *laser* node publishes and *mapping* node subscribes.

**NOTE:** In reality a bit more complicated:
- Laser node does not have to register first
- Multiple publishers and multiple subscribers
- But same outcome - **peer-to-peer data transfer**
Node/Topic Example

```
+laser
+  /laser/parameter_descriptions
+  /laser/parameter_updates
+  /diagnostics
+  /tf

+map
+  /image
+  /localmap

+map_view
```
Nodes in a Distributed System

• Nodes can be on different computers.
• Requires some care:
  – Turn off local firewalls
  – Environment variables to specify addresses of nodes and master:
    • ROS_MASTER_URI - location of the master.
    • ROS_HOSTNAME - node will register with master using this value.
  – Safest to use IP addresses (not hostnames).

```bash
export ROS_MASTER_URI=http://192.168.1.2:11311
export ROS_HOSTNAME=192.168.1.5
```

IP Address of robot
Packages – Flexible Structure

- Dependencies to other packages.
- Custom *messages* and *service* definitions.
- Specify nodes - 0 or more.
- Libraries – export for use by other packages.
Catkin Workspaces

- Used for compiling and running a catkin system.
- Workspace layout:
  
  ```
  catkin_ws/
  src/my_package/          - individual packages placed here
  build/                  
  devel/                  - install location for development files
  ```

- Catkin tools are run within workspace directory.
- To compile your workspace:
  
  ```
  $ cd catkin_ws
  $ catkin_make
  ```
Catkin Packages

- Catkin – the ROS build system:
  - Combines CMake (popular C++ build tool) and some Python components.

- User-built components are organised in packages.

- A typical package:

```
mypackage/
    CMakeLists.txt    - CMake building
    package.xml      - dependencies between packages
    src/             - source directory: C++/Python/Java/etc
    include/         - typical for C++ headers
    scripts/         - typical for Python
    setup.py         - python installation file
```

- Use the Catkin tools: `catkin_create_pkg` my_package depend1 ...
Names and Namespaces - Warning

- ROS uses namespaces in different contexts.
- Positive: easy to avoid name clashes.
- Negative: can create confusion.
- Do not confuse namespace usage in:
  - Node names.
  - Topic names.
  - Frames of reference – to be discussed later.
- Node name “/mynode/laser” is different from frame “/mynode/laser”.
Laboratories

- Work through the ROS tutorials.

- First assignment:
  - due week 5.
  - Turtlebot3 navigation and recognition task.
  - Get started now!