Introduction to ROS and the simulation

ST5 Autonomous robotics

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Introduction

Autonomous Robots

- anatomy
- functions
  - perception
  - action
  - decision
  - learning
  - interaction

Aim of this session

- main ROS concepts
- some ROS tools
- simulation and robots

Need for a middleware

Robotic system

- many hardware components:
  - computers
  - network
  - motor controllers
  - sensors...
- many software components:
  - operating system
  - drivers
  - control
  - perception...
- research

Putting it all together: middleware

ROS is a middleware

Robot Operating System

- open-source middleware
- development environment
- communication library and tools
- packaging system
- plenty of existing modules
- community

What ROS is not

Robot Operating System

- *not* a (computer) operating system
  - official: Ubuntu Linux
  - experimental support for: macos, MS Windows, Fedora, Gentoo, Debian...
- not a programming language
  - official: C++, Python (2 until melodic)
  - experimental: Java, Lisp, Octave...
- not a hard real-time environment
- not designed for micro-controllers

01

Concepts

Structure

Central concept

- processing

Processing units

- node (unix process)
- nodelet (thread)

Organization

- package: compilation unit
  - node(s)
  - message definitions
- `catkin`
  - build system based on `cmake`
  - dependency handling
  - packaging/deployment

Communication

Communication between nodes

- message
  - message passing
  - grouped in topics
- *services*
  - remote procedure call
  - pair of request and answer messages
- *actions*
  - tasks with significant duration
  - preemptible
  - continuous feedback
- statically typed

Topics

Initialization

- publisher: node declaring writing on a topic
- subscriber: node declaring listening to a topic
- several publishers/subscribers allowed
- order irrelevant
- require a directory

Communication

- publisher transmits to each subscriber
- no need for the directory

Services

Initialization

- *server*: node advertising a service
- *client*: node asking for a proxy on a given service
- require a directory

Request

- client sends a *request* to the server
- server processes and sends the *answer* back
- no need for the directory

Actions

Initialization

- *action server*: node advertising an action
- *action client*: node asking connection to an action server
- require a directory

Request and execution

- client sends a *goal*
- server starts execution (interrupting current task if needed)
- server gives goal task reference to client
- server gives continuous *feedback*
- task finished: server reports *result*
- no need for a directory

rosmaster

rosmaster

- directory
  - publishers
  - subscribers
  - services
  - actions
- provides an XML-RPC API
- *not* a central communication node
- part of `roscore`
- nodes know of it through the `ROS_MASTER_URI` shell environment variable

roscore

roscore

- executable with three roles
  - `rosmaster`
  - parameter server
  - log aggregator (`/rosout`)

Parameter server

- centralized parameter repository
- XML-RPC data types

Log aggregator

- republish log messages at lower rate

Launching

Launching a robotic system

- several/many processes
- on different computers
- with specific configuration and parameters

Launch files

- list of nodes
- arguments and parameters
- XML syntax

Transformation frames

Robot

- set of rigid bodies

In ROS

- set of transformation frames
- linked by transformations
- arranged in a directed tree
- published on a single `/tf` topic[a]
- rich API to extract information

[a] and `/tf_static` too

Summary of concepts

Structure

- nodes, in packages

Communication

- messages
- services
- actions
- peer-to-peer

Launching

- launch files

Transformations

- `/tf`

02

Tools and third party

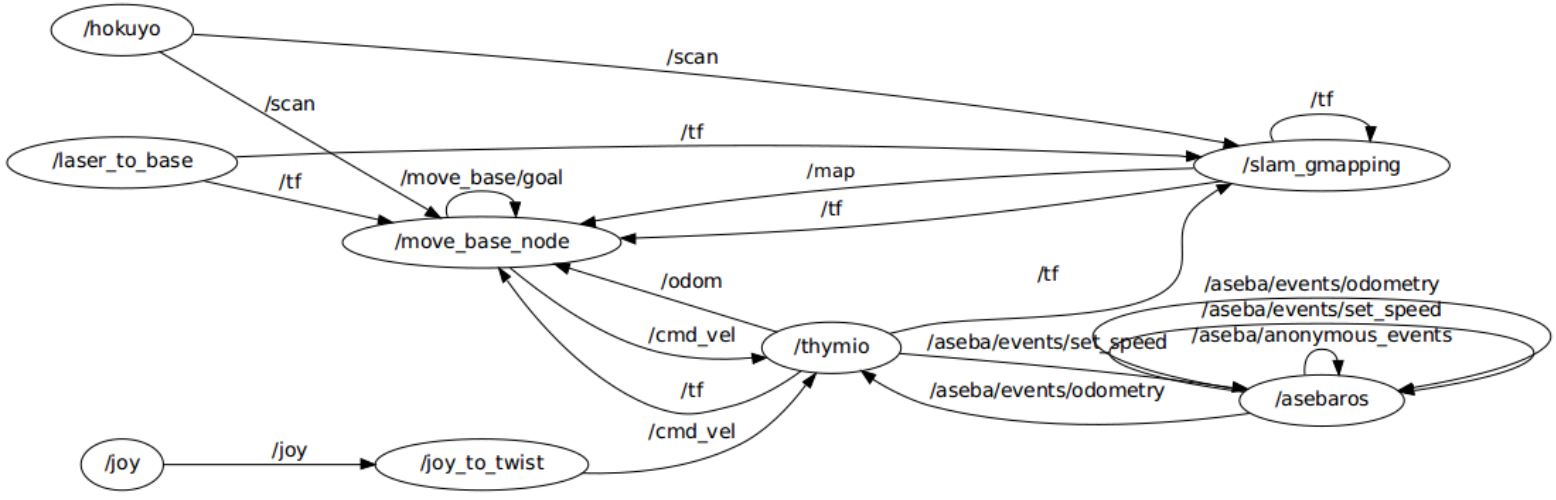
Runtime inspection

Nodes:

- list nodes
- get communication information

Connection

- `rqt_graph`



Runtime inspection

Topics

- list topics
- see messages
- get type information

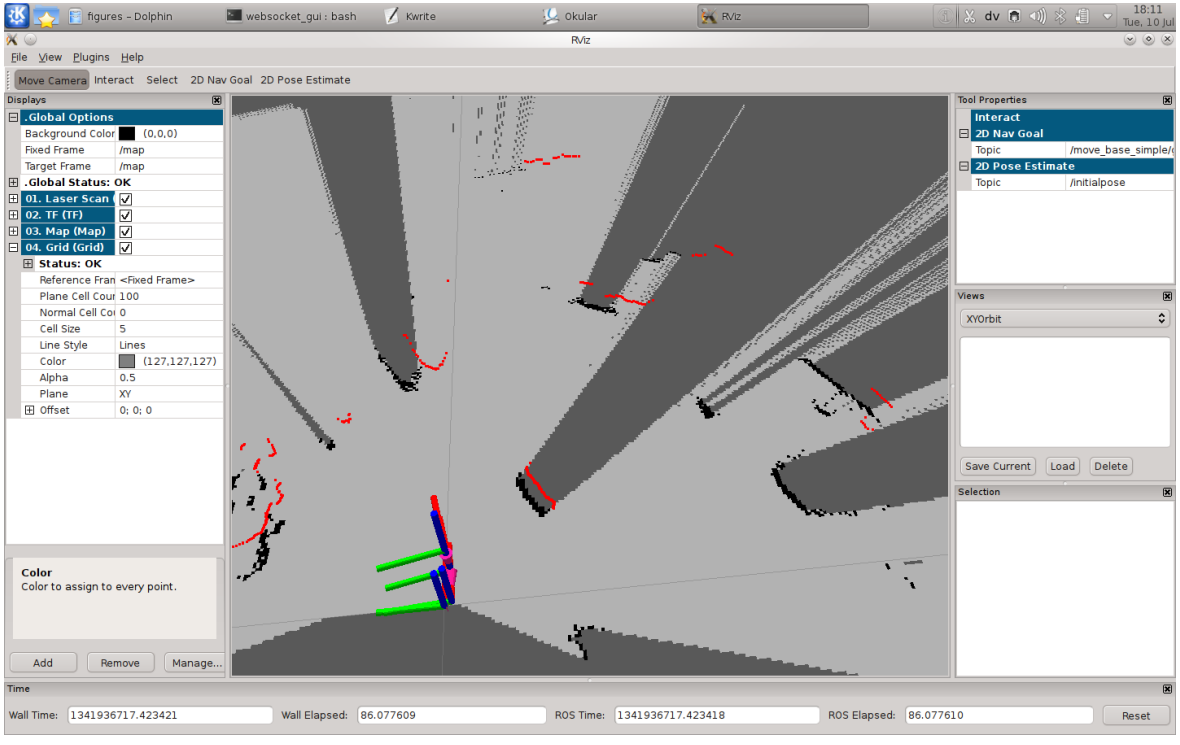
`/tf`

- inspect `/tf` tree
- compute transformations

Visualization

`rviz`

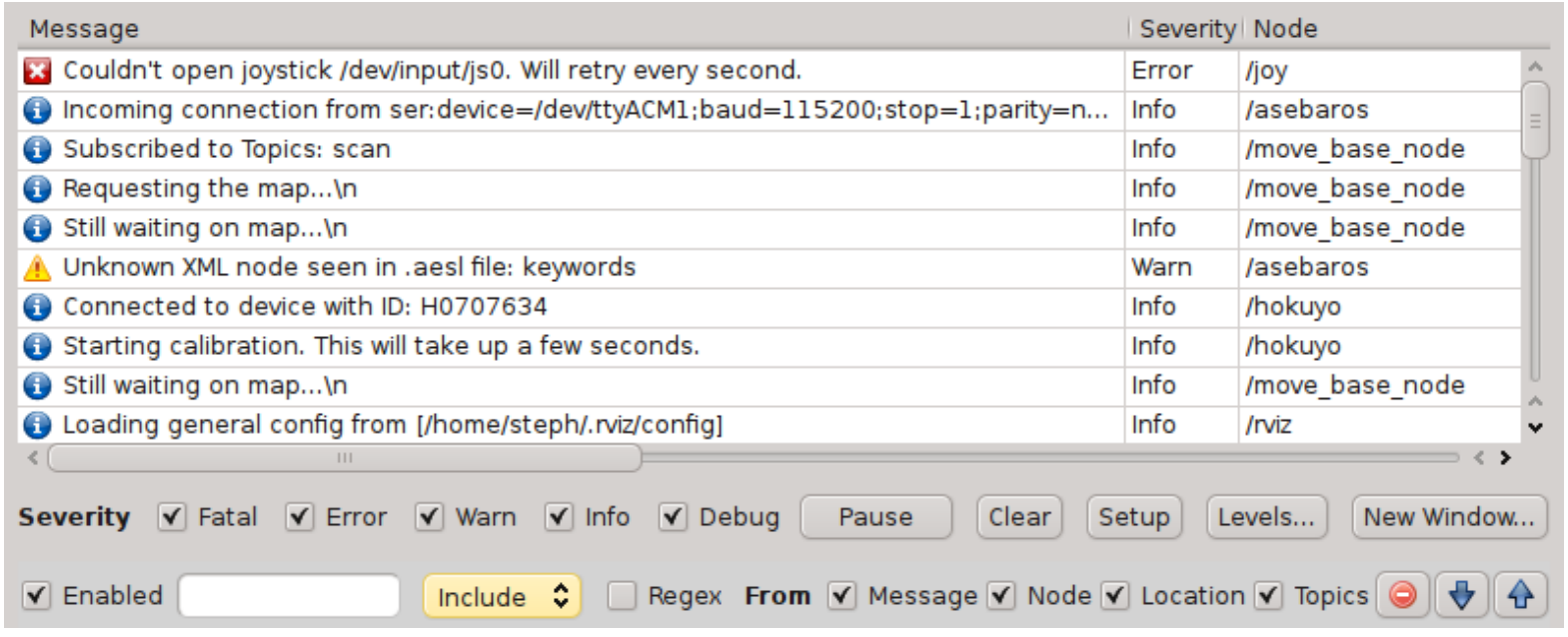
- full 3D visualization
- configurable graphical interface



Logging

Logging API

- different verbosity levels
- published on `/rosout`
- `rqt_console` for online inspection
- automatic dumping to file system for offline analysis



Recording

Recording messages

- container: *bagfile*
- `rosbag`: generic subscriber

Replaying messages

- `rosbag`: generic publisher
- offline testing of perception pipeline
- handling of time

Third party tools

Hardware drivers

- plenty of common sensors
- many actuators
- some/many robots

Software stacks

- several mapping/SLAM implementations
- navigation, motion planning
- 3D perception
- several simulators...

Important community

- researchers
- some companies (robot/sensors manufacturers)

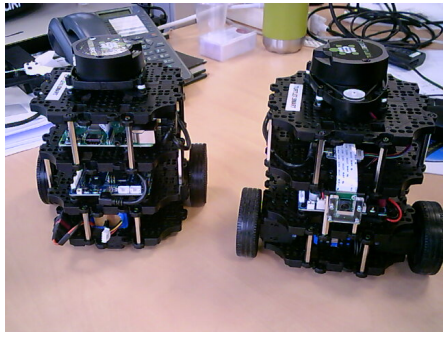
03

ST5: Simulation and robots

ST5: Robots

Turtlebot2 / Turtlebot3 burger

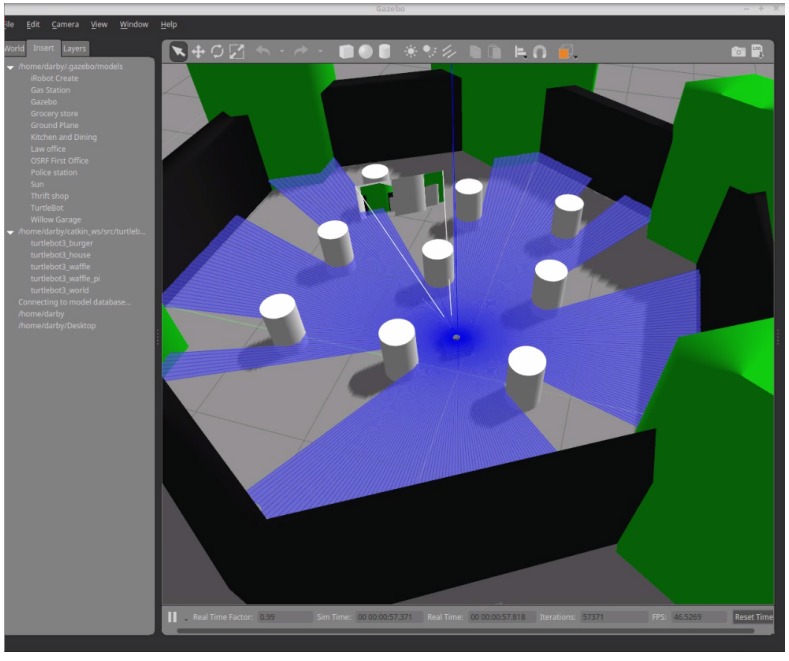
- 2D ground robot
- differential drive
- with 2D laser scanner



ST5: Simulation

Simulation

- easier and safer than a real robot
- `gazebo` simulator
- `turtlebot3` robot



04

Conclusion

Conclusion

ROS

- open-source middleware for robotics (not the first/only)
- communication API
- build environment
- launch capabilities
- huge community and plenty of software available
- transitioning to ROS2

ST5

- development in ROS noetic (Python3)
- use of simulation
- final tests on real robots

Thanks for your attention

Questions?