Introduction to ROS

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Introduction

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,
- existing modules,
- community.

What ROS is not

Robot Operating System:

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

Outline

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Concepts

Structure

Central concept:

- processing,

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Processing units:

- node (process),
- nodelet (thread);

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Processing units:

- node (process),
- nodelet (thread);

Organization:

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

Communication

Communication between nodes:

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  - grouped in topics;

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- actions:
  - tasks with significant duration,
  - preemptible,
  - given feedback;

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- services:
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- actions:
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  - given feedback;
- statically typed.

Topics

Initialization:

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Communication:

- publisher transmits to each subscriber,
- no need for directory.

Services

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Request:

- client sends a request,
- server processes and answers,
- no need for directory.

Actions

Initialization:

- action server: node advertising an action server,
- action client: node asking connection to action server,

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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 report result,
- no need for directory.

`rosmaster`

`rosmaster`

- directory:
  - publishers,
  - subscribers,
  - services;
- provides XMLRPC API;
- not a central communication node;
- part of `roscore`;
- nodes know of it through `ROS_MASTER_URI` environment variable.

`roscore`

`roscore`:

- `rosmaster`,
- parameter server,
- log aggregator.

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Parameter server:

- centralized parameter repository,
- XMLRPC data types.

Launching

Launching a robotic system:

- several processes,
- on different computers;

Launch files specify:

- list of nodes,
- parameter values,
- in XML syntax.

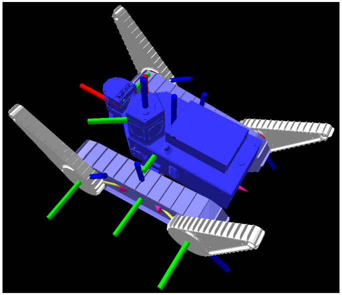
Transformation frames

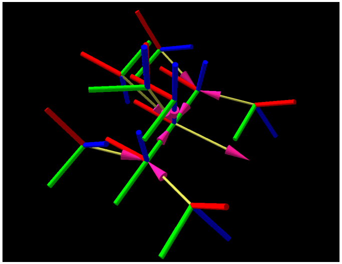
Robot:

- set of rigid bodies

In ROS:

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





Summary of concepts

Structure:

- nodes, in packages;

Communication:

- messages,
- services,
- actions,
- peer-to-peer;

Launching:

- launch files;

Transformations:

- `/tf`.

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Tools and third party

Runtime inspection

Nodes:

- list nodes,
- get communication information;

Runtime inspection

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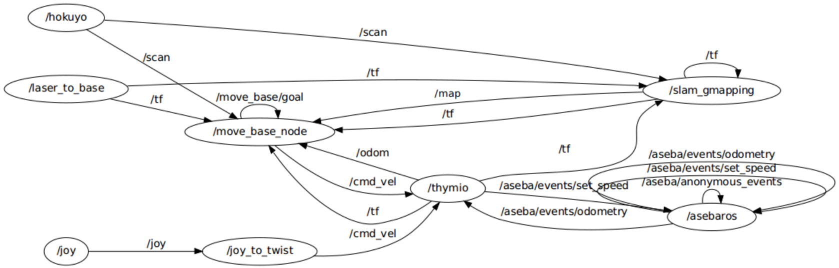
Connection:

- `rqtgraph`



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Topics:

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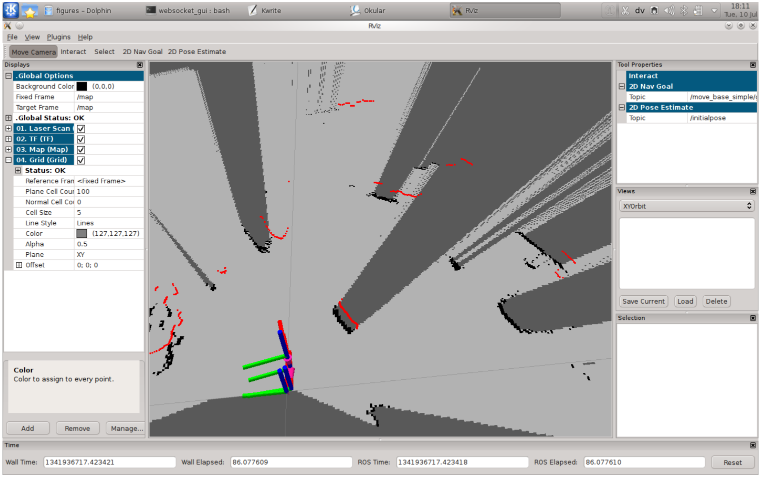
`/tf`:

- inspect `/tf` tree,
- compute transformations;

Visualization

`rviz`:

- configurable graphical interface



Displays

.Global Options	
Background Color	⬛ (0,0,0)
Fixed Frame	/map
Target Frame	/map
.Global Status: OK	
01. Laser Scan	✓
02. TF (TF)	✓
03. Map (Map)	✓
04. Grid (Grid)	✓
Status: OK	
Reference Fran	<Fixed Frame>
Plane Cell Cour	100
Normal Cell Co	0
Cell Size	5
Line Style	Lines
Color	▨ (127,127,127)
Alpha	0.5
Plane	XY
Offset	0; 0; 0

Color
Color to assign to every point.

Tool Properties

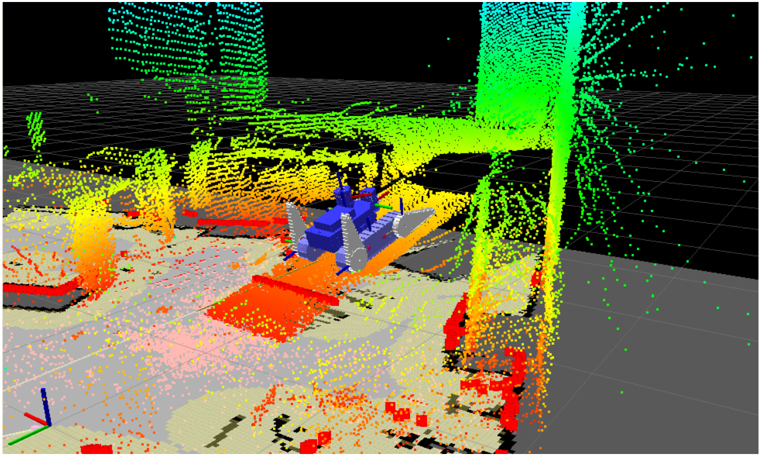
Interact	
2D Nav Goal	
Topic	/move_base_simple/
2D Pose Estimate	
Topic	/initialpose

Wall Time: 1341936717.423421 Wall Elapsed: 86.077609 ROS Time: 1341936717.423418 ROS Elapsed: 86.077610

Visualization

`rviz`:

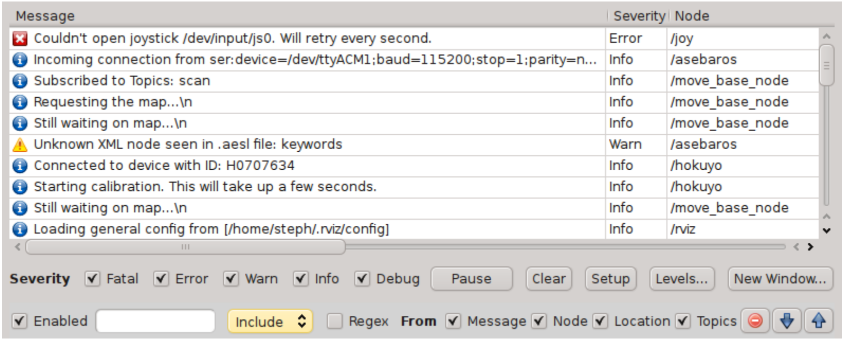
- full 3D visualization



Logging

Logging API:

- different verbosity levels,
- published on `rosout`,
- `rqtconsole` for online inspection,
- automatic dumping to file system for offline analysis.



```
Message                                                                      Severity  Node
Couldn't open joystick /dev/input/js0. Will retry every second.              Error     /joy
Incoming connection from ser:device=/dev/ttyACM1;baud=115200;stop=1;parity=n...  Info  /asebaros
Subscribed to Topics: scan                                                   Info      /move_base_node
Requesting the map...\n                                                      Info      /move_base_node
Still waiting on map...\n                                                    Info      /move_base_node
Unknown XML node seen in .aesl file: keywords                                Warn      /asebaros
Connected to device with ID: H0707634                                        Info      /hokuyo
Starting calibration. This will take up a few seconds.                       Info      /hokuyo
Still waiting on map...\n                                                    Info      /move_base_node
Loading general config from [/home/steph/.rviz/config]                       Info      /rviz
```

Severity ✓ Fatal ✓ Error ✓ Warn ✓ Info ✓ Debug — Pause, Clear, Setup, Levels..., New Window...

✓ Enabled — Include — ☐ Regex — From ✓ Message ✓ Node ✓ Location ✓ Topics

Recording

Recording messages:

- container: bagfile,
- `rosbag`: generic subscriber;

Replaying messages:

- `rosbag`: generic publisher,
- offline testing of perception pipeline.

Third party tools

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- some actuators,
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Software stacks:

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- navigation,
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Important community.

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Impact around the world:

- umbrella project providing a default choice,
- increasing code exchange between researchers,
- standardization of data types, additional conventions,
- strong set of development and monitoring tools.

The Challenges

Uncontrolled growth:

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- Who specifies what? Is there continuity?

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ROS2.0:

- multi-robot, realtime, embedded, production-ready;
- DDS as communication backend,
- API change,
- ???

Thanks for your attention.