ROSPlan

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Course structure

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1. ROS
2. ROSPlan
3. Q+A

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1. **ROS**
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3. Q+A

What is ROS?

- ROS = Robot Operating System
- *Not really an operating system, but is easier to explain in the business world this way…*
- ROS = (A) plumbing + (B) tools + (C) capabilities + (D) ecosystem (Brian Gerkey)
- (A) provides publish-subscribe messaging infrastructure designed to support the quick and easy construction of distributed computing systems.

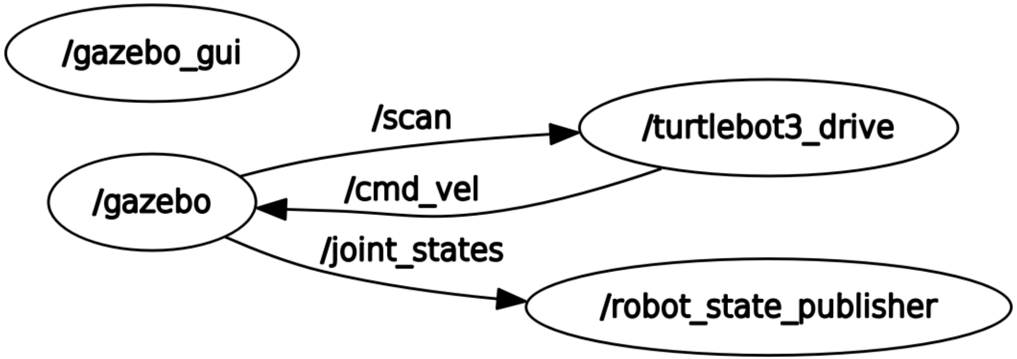
- Source: https://answers.ros.org/question/12230/what-is-ros-exactly-middleware-framework-operating-system/

What is ROS? (A) plumbing + (B) tools + (C) capability + (D) ecosystem

- (B) ROS provides an extensive set of tools for configuring, starting, introspecting, debugging, visualizing, logging, testing, and stopping distributed computing systems.
- (C) ROS provides a broad collection of libraries that implement useful robot functionality, with a focus on mobility, manipulation, and perception.
- (D) ROS is supported and improved by a large community, with a strong focus on integration and documentation. ros.org is a one-stop-shop for finding and learning about the thousands of ROS packages that are available from developers around the world.

Basic concept 1 : Node

- **Node : a process that performs computation**
- Nodes are combined together into a graph and communicate with one another using topics, services, actionlib and the Parameter Server
- Nodes may reside in different machines transparently



Basic concept 2: Topic

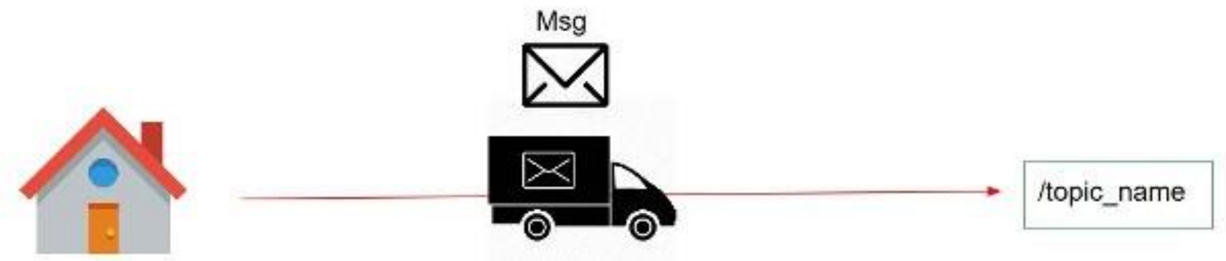
- Topics: Named buses (pipes) over which nodes exchange messages.
- Producer – Consumer design pattern
- In general, nodes are not aware of who they are communicating with.
- nodes that are interested in data ***subscribe*** to the relevant topic.
- nodes that generate data ***publish*** to the relevant topic.

Properties of topics

- There can be multiple publishers and subscribers to a topic.
- Intended for unidirectional, streaming communication.
- Nodes communicate with each other by publishing **messages** to topics.
- An active topic can only have a single **message** type at a time.

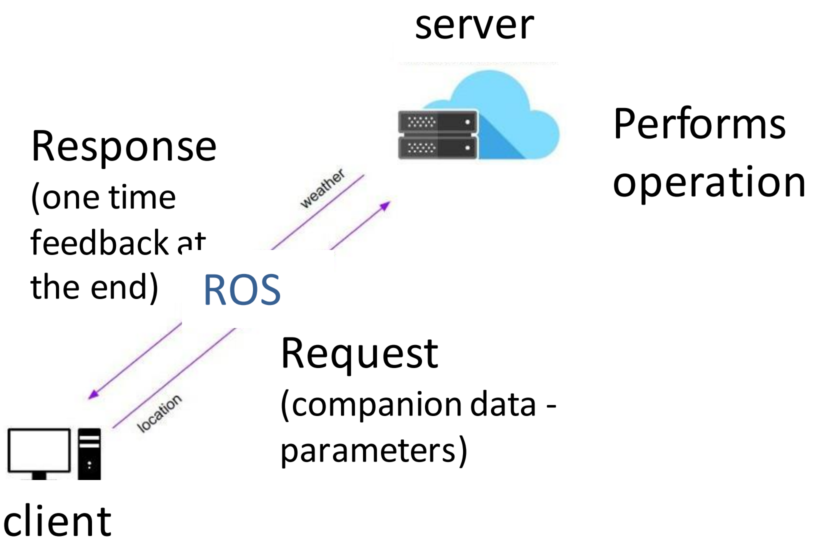
Basic concept 3: Messages

- Earlier we saw that nodes can make connections with each other via topics.
- Informally the message can be seen as the envelope you send via post.
- Messages state what kind of information your nodes need to produce in order to communicate together.



Basic concept 4: Service

- Service: is a client/server communication request system.
- There is no feedback while the operation is being performed but only one time at the end.



Typically is a blocking operation, but you can specify a timeout...

Basic concept 5: actionlib

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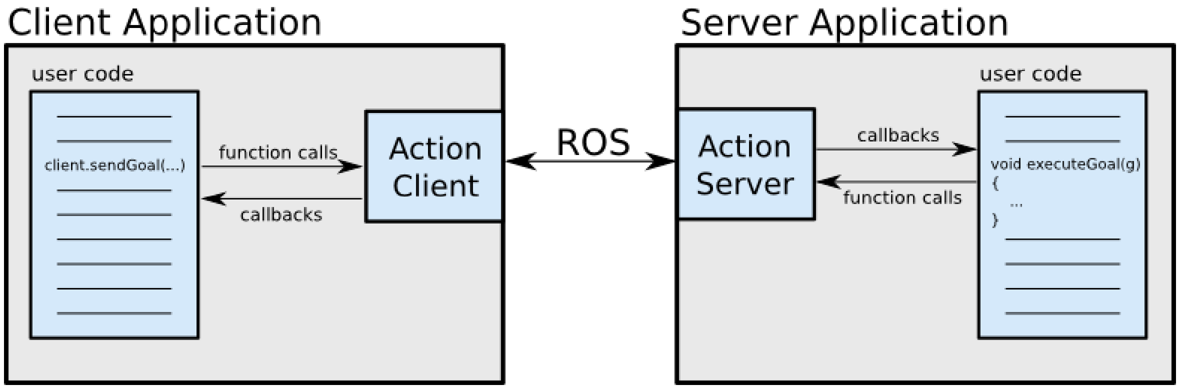
- Similar to services but additionally you can:
  - Get periodic feedback about the progress of the request
  - Temporarily interrupt a task being carried out
  - Cancel the request



Development in ROS

- Mainly C++ and Python are supported.
- Experimental support for multiple other languages:
  - e.g. Java, lisp, nodejs, lua, ruby, R, Go, etc.
- Code is organized in ROS **packages** that live inside "catkin" workspaces (development folder).
- A catkin workspace is a folder where you modify, build, and install ROS **packages**.

ROS bash

- Offers a set of shell ROS commands
- rosbash enables tab completion on: roslaunch, rosparam, rosnode, rostopic,rosservice, rosmsg, rossrv, rosbag.
- Most popular include:
- roscd pkgname (cd to pkgname easily)
- rosed pkgname filename (quickly edit a file)
- roscat pkgname filename (quickly visualize a file in terminal)
- rosrun pkgname executable (run executable from anywhere without having to give its full path)

Some important libraries 1/4

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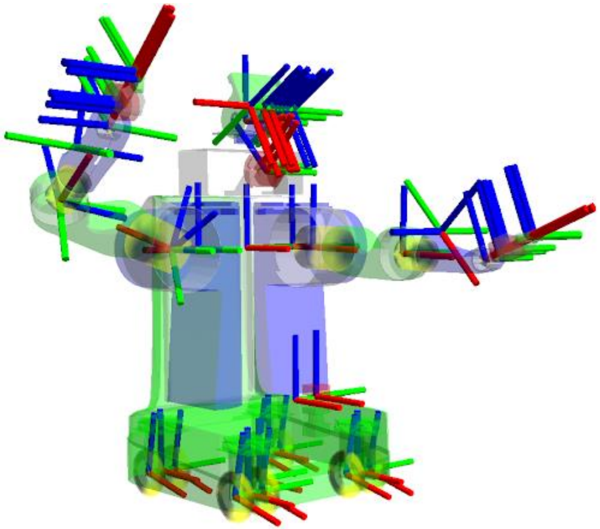
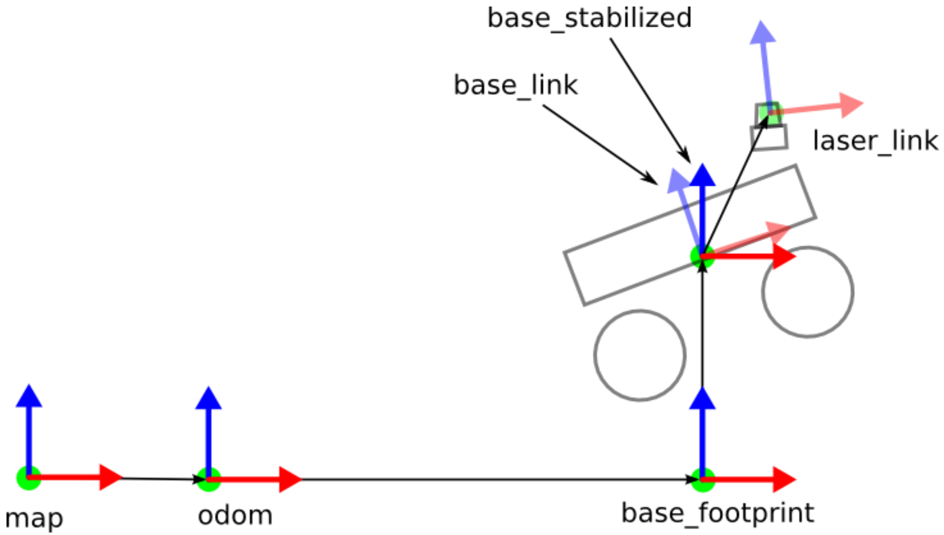
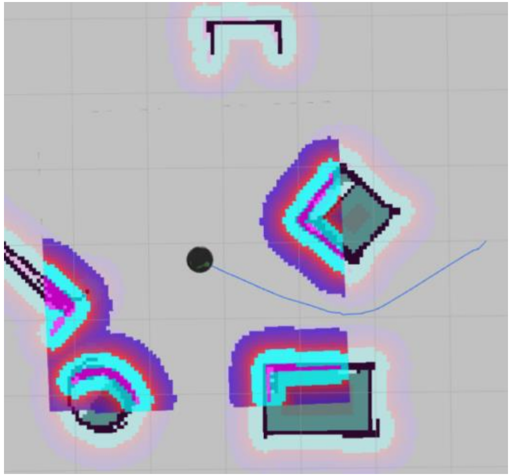
- **tf** : Library to keep track of multiple coordinate frames over time.
- Users can transform points, vectors, etc between any two coordinate frames at any desired point in time.

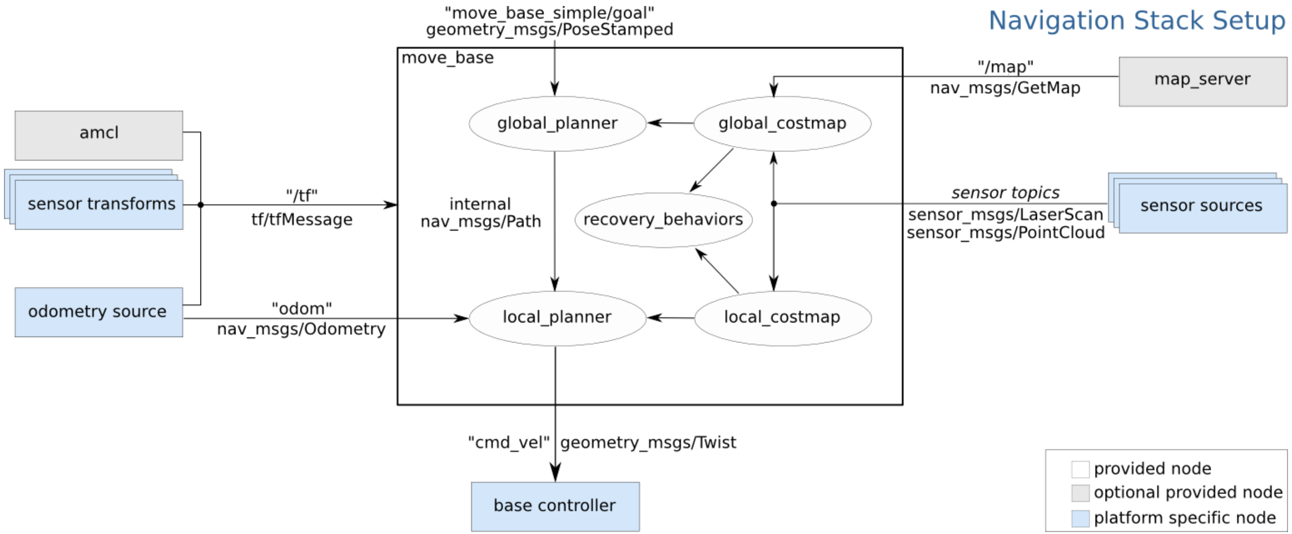




Some important libraries 2/4

- **move_base**





Some important libraries 3/4

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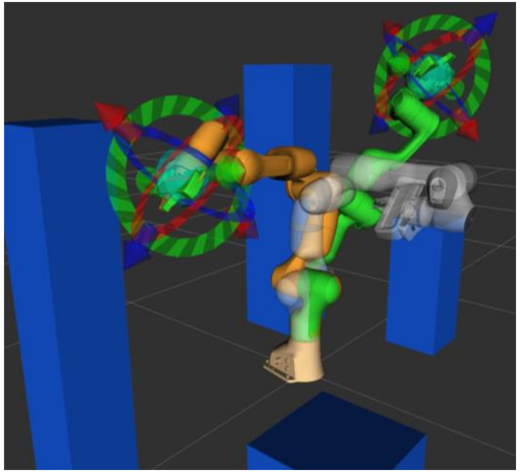
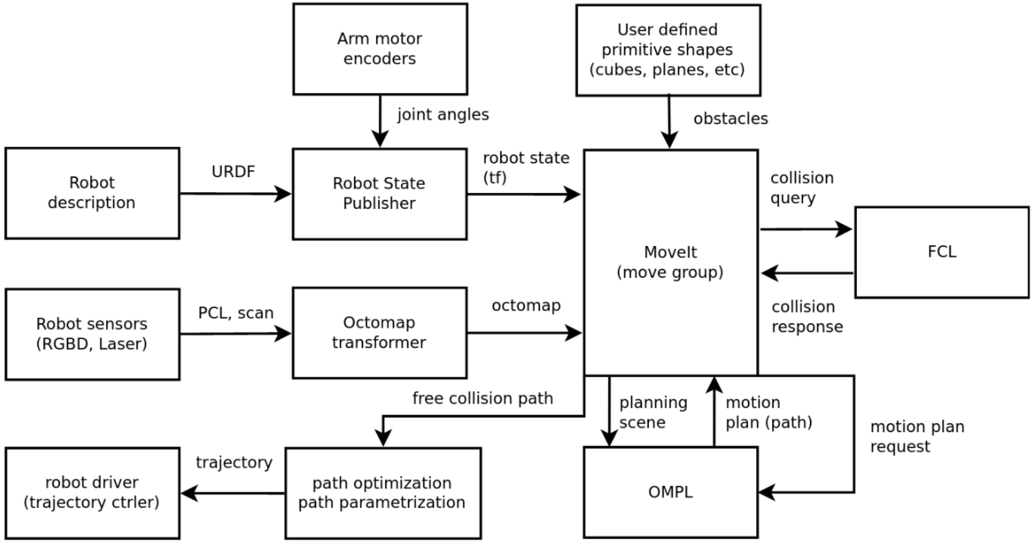
MoveIt!

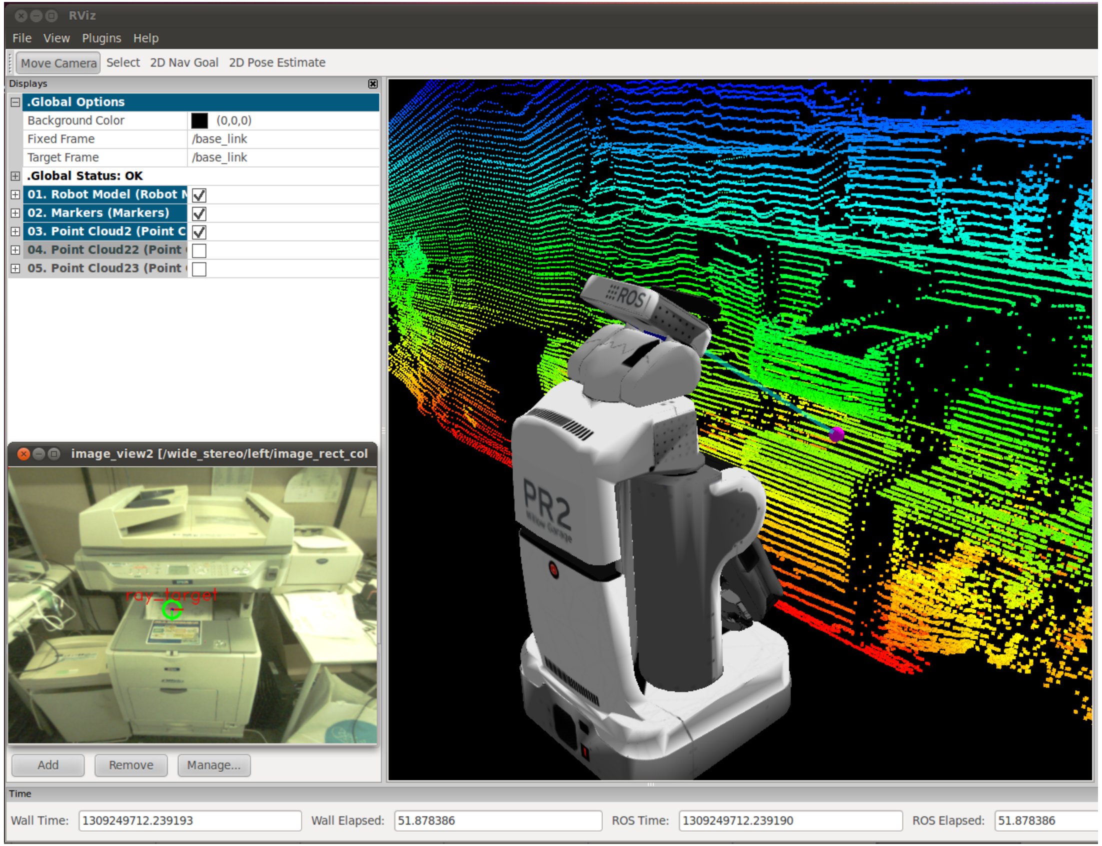




Some important libraries 4/4

- **Rviz**

3D visualisation tool for ROS



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ROSPlan

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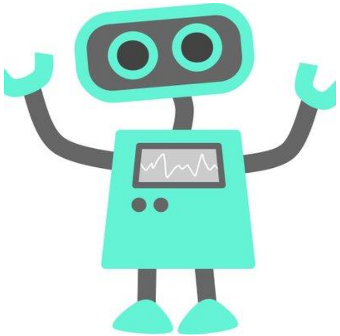
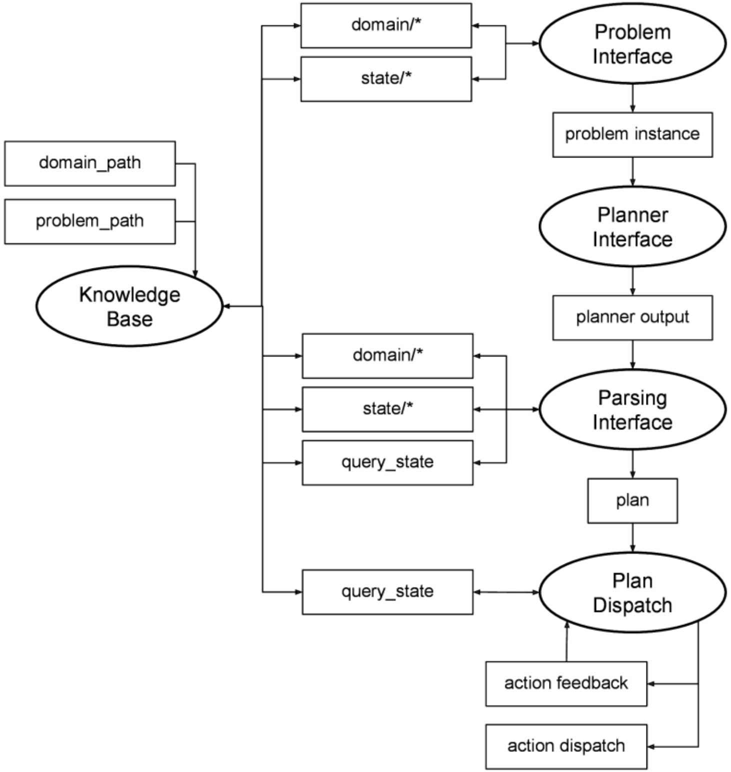
- *"The ROSPlan framework provides a generic method for task planning in a ROS system".*
- First step towards integration of AI planning and robotics.
- Uses different technologies to provide with high level robot control.
- Main support: PDDL 2.1
- Experimental support: PPDDL, RDDL, HDDL (**HTN** new!)
- Plan execution and monitoring via:
  - Simple plan dispatch or Esterel plan dispatch



Architecture

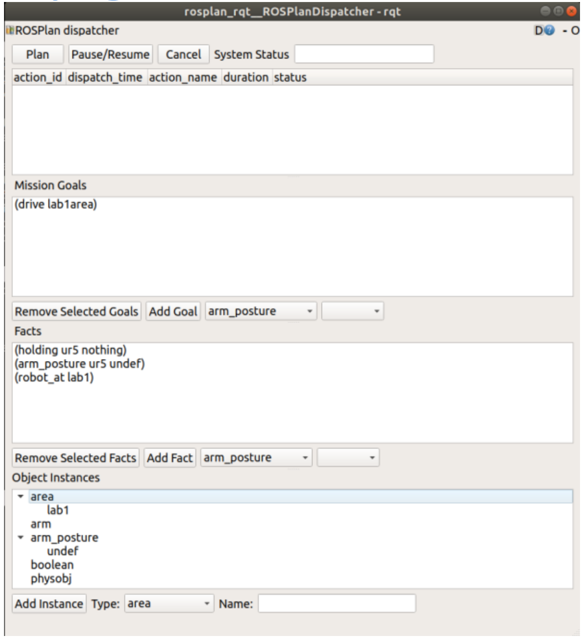


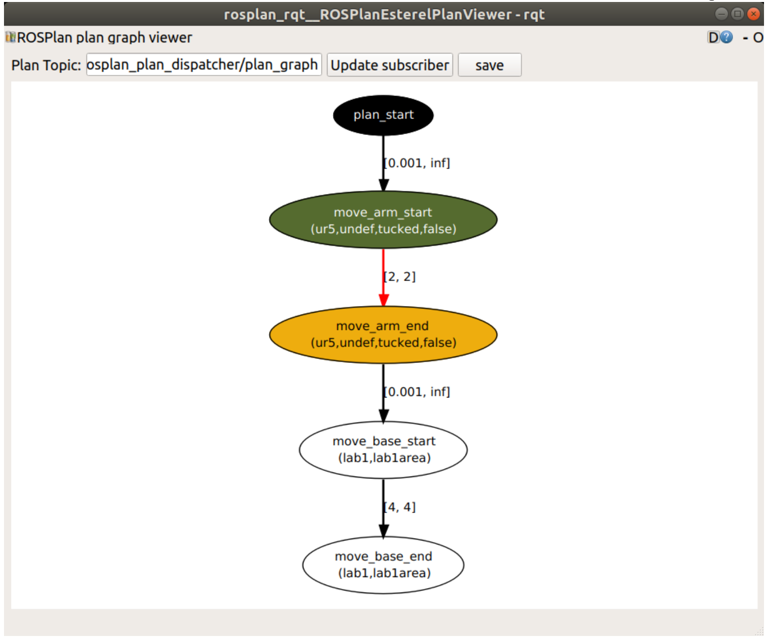
Components

- Knowledge Base (KB) : stores the (symbolic) planning model (domain and state); Communication via services
- Problem interface : query state from KB and create a problem instance
- Planner interface : wrapper around the AI planner, write its output to a topic
- Parsing interface : Convert planner output into a representation suitable for execution
- Plan dispatch : Execution and monitoring layer

Debugging tools

- KB rqt gui : KB visualisation/manipulation
- Esterel rqt gui : Plan visualisation and realtime execution progress





ROSPlan KB gui

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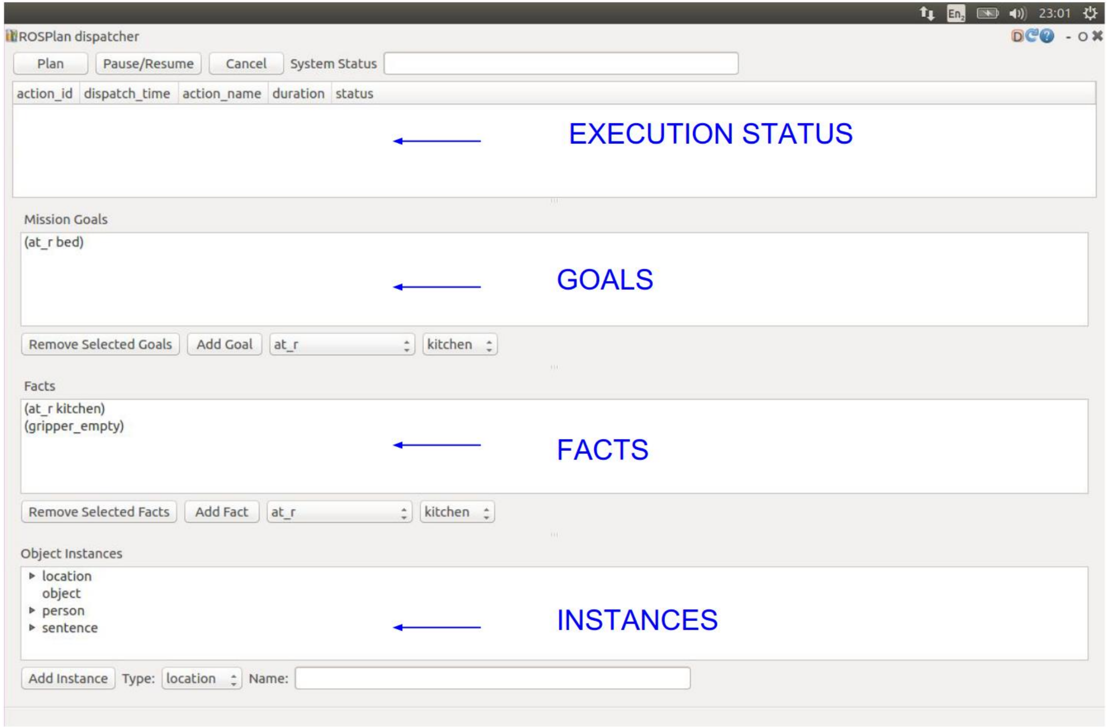
- Command: rqt --standalone rosplan_rqt.dispatcher.ROSPlanDispatcher



Action interface (RPActionInterface)

- Provides a base class implementation to ease the process of robot action creation
- Available in C++ and Python
- Steps:
- 1) Subscribe to the plan
- 2) If action is not relevant, exit
- 3) Send actionlib feedback telling the action is enabled
- 4) Provide virtual function for concrete implementation
- 5) Upon action success, update KB according to the model
- 4) Send actionlib result (action achieved or failed)

Simulated Actions (RPSimulatedActionInterface)

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- Syntethic simulator of actions
- Made as a replacement of a physics-based robot simulator
- Make multiple mockup actions, useful for testing/debugging
- Parameters:
  - action_duration
  - action_duration_stddev
  - action_probability

Esterel plan dispatch

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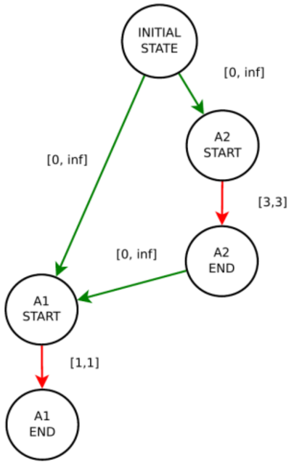
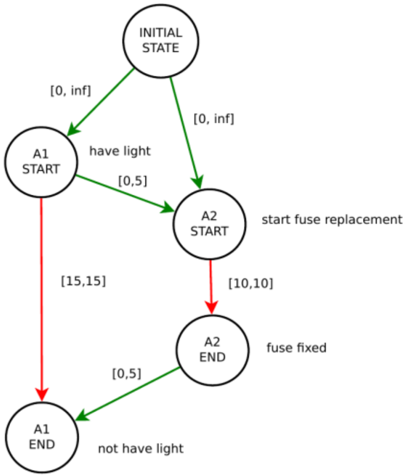
- Realtime graph-based algorithm for plan execution - monitoring
- Support for concurrent actions
- Preconditions are checked before sending action for execution

- In a nutshell: Converts a temporal PDDL planner output into a graph, which edges represent ordering constraints.

Semantics behind edges

- Conditional edge encapsulates 1 or more casual links
- All edges specify ordering constraints: source node effects need to
- happen before sink node gets signal
- Node cannot fire unless it has received all incoming edges / signals
- Examples:





Esterel plan dispatch explanation 1/4

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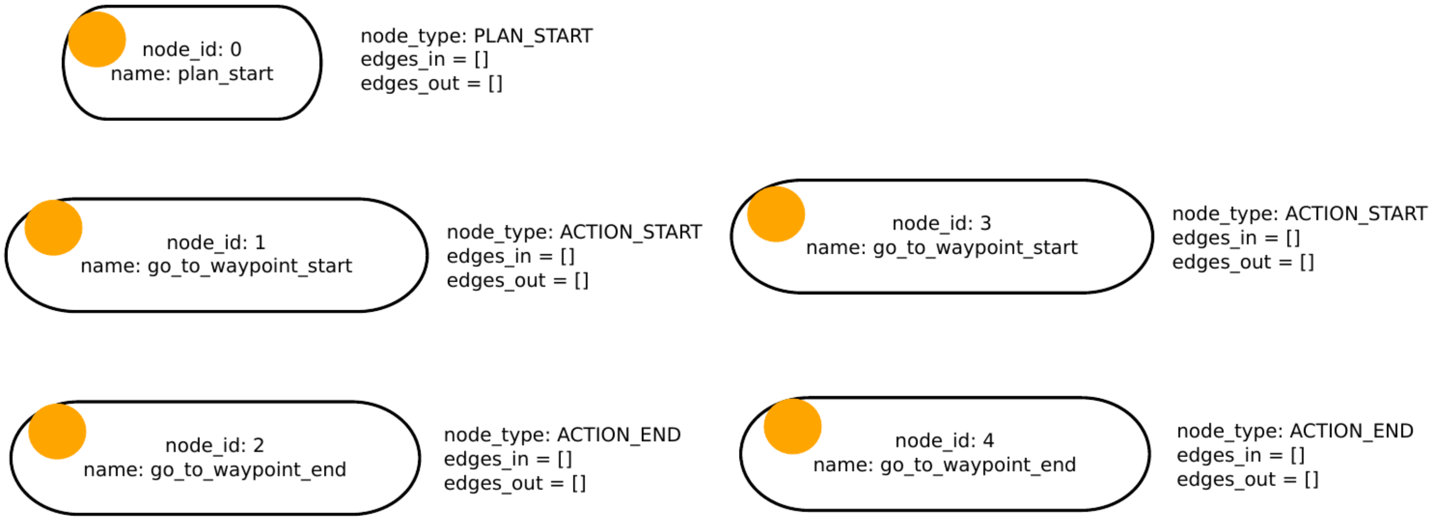
step 1 : PreparePlan() output

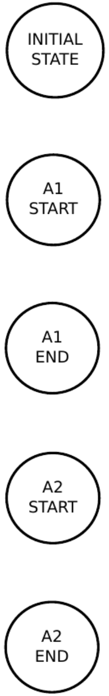
planner output example:
===
10.001: (goto_waypoint kenny wp0 wp1) [10.000]
20.002: (goto_waypoint kenny wp1 wp2) [10.000]

Node associated action (not displayed)

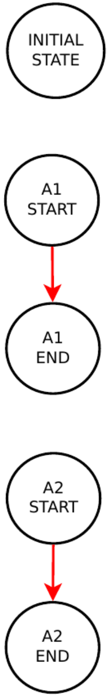


Esterel plan dispatch explanation 2/4

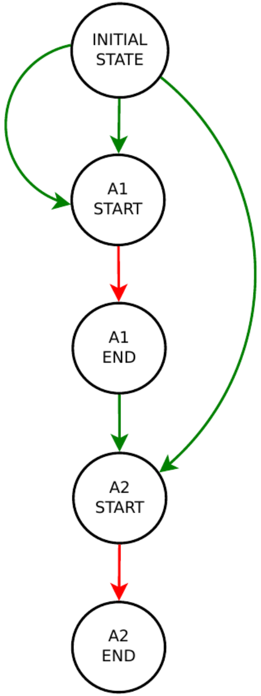
step 2 : order nodes by dispatch time



step 3 : create start-end action edges



step 4 : create conditional support edges



Esterel plan dispatch explanation 3/4

- Interference edge
- a and b interfere if:

$$eff^{+}a \cap eff^{-}b \neq \emptyset$$

$$pre^{+}a \cap eff^{-}b \neq \emptyset \; *$$

$$pre^{-}a \cap eff^{+}b \neq \emptyset \; *$$

$$eff^{n}a \cap eff^{n}b \neq \emptyset$$

- ROSPlan currently checks the ones marked with *

Esterel plan dispatch explanation 4/4

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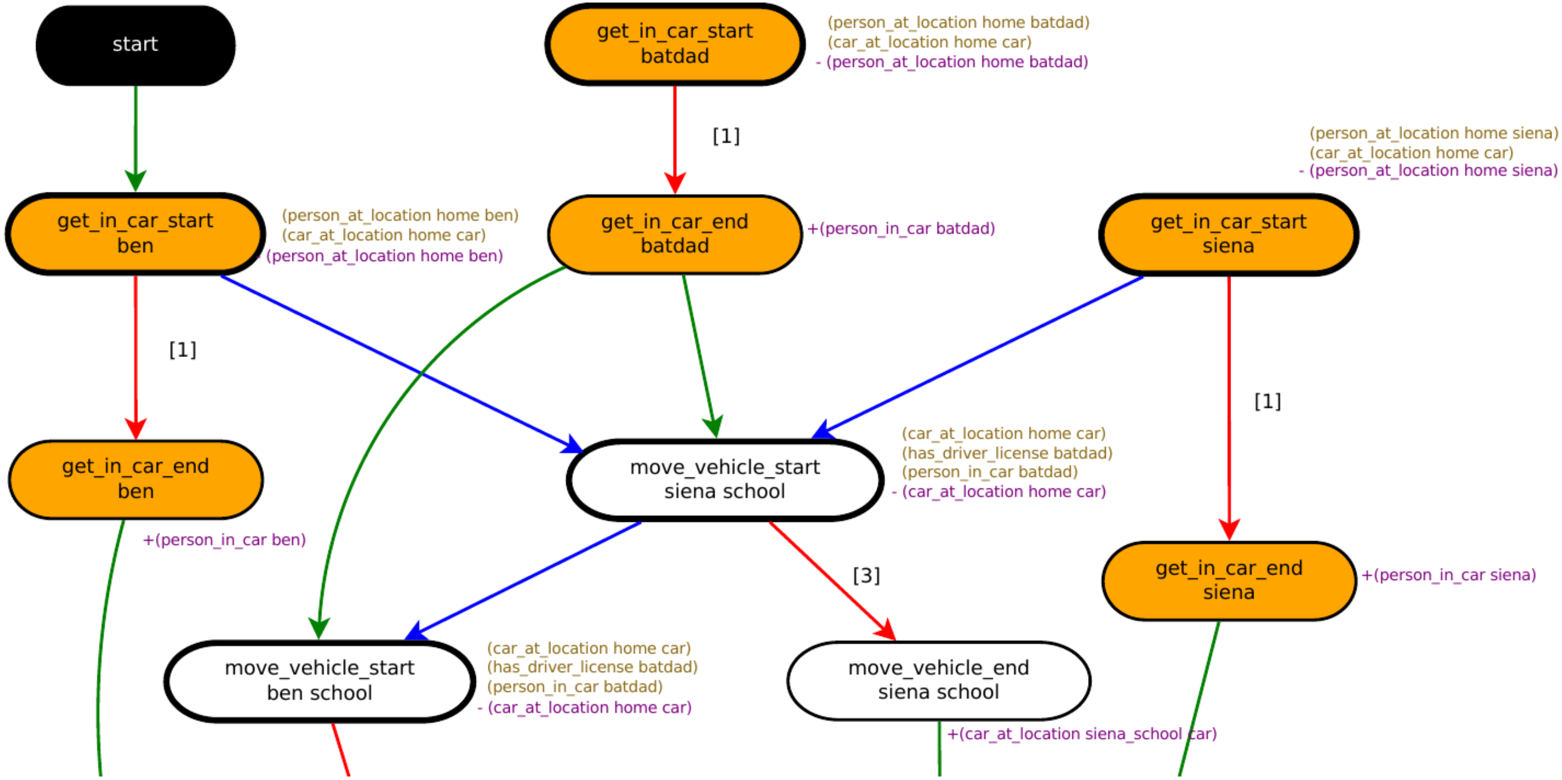
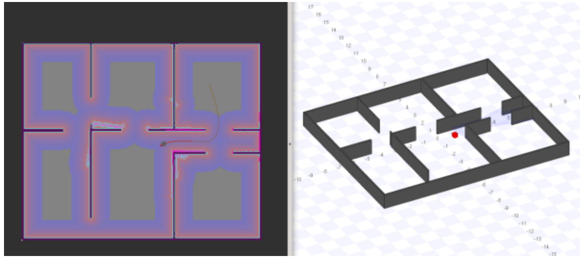
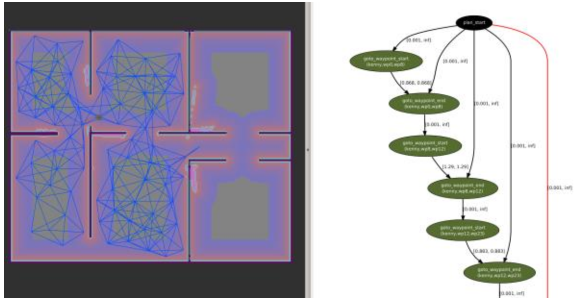


ROSPlan demos

- Example launch file on how to launch a turtlebot3 robot in **stage** simulator

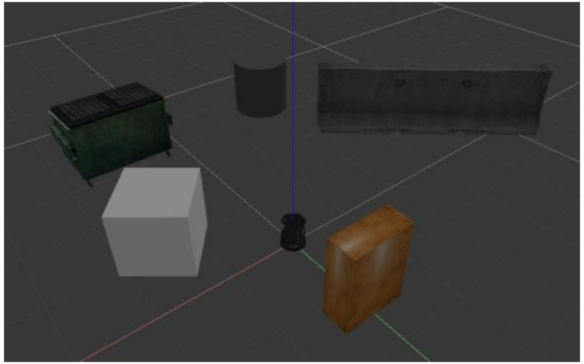


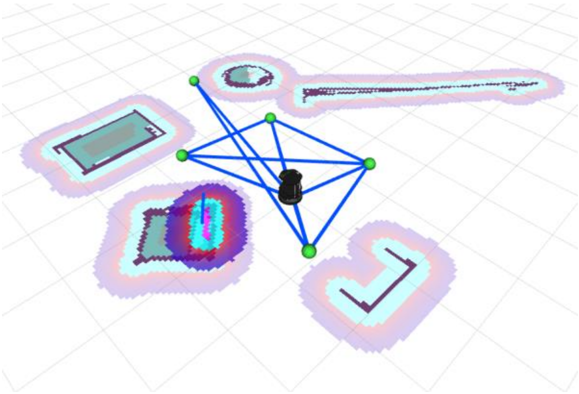
- **Exploration** demo in stage



ROSPlan demos

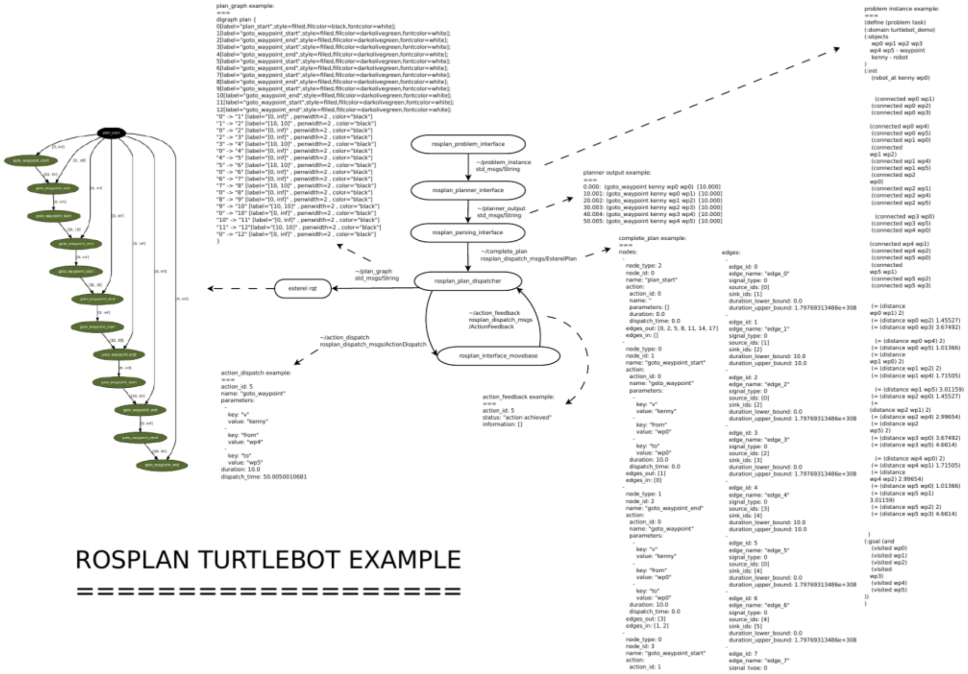
- Turtlebot exploration demo in Gazebo





ROSPlan turtlebot demo

- https://github.com/oscar-lima/rosplan_debug/blob/kinetic/rpd_turtlebot_demo/ros/doc/rosplan_turtlebot_example_detail.pdf



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