ROSPlan is a framework for controlling ROS systems with Planning.

Outline of tutorial:

1. Practice with ROS
2. Write PDDL domains for robots
3. Learn how to use ROSPlan
4. Hands-on with the Turtlebot2

"ROSPlan: Planning in the Robot Operating System"

https://github.com/KCL-Planning/ROSPlan/wiki
ROS (the Robot Operating System) is an open-source library for robotics.

Core concepts of ROS:
- Packages
- Nodes
- Messages

Packages contain nodes and messages.
Some example packages:

ros-indigo-navigation
ros-indigo-turtlebot
ros-indigo-mongodb-store
ros-indigo-spacnav-node
rosplan
Components in ROS run as nodes. Nodes can be distributed across different computers.

A node might take input and produce output.

Example node:

- move_base (navigation)
  - inputs desired location, transforms (positional data)
  - outputs velocity
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A node might take input and produce output.

Example node:

- amcl (odometry)
- inputs scan data
- outputs transform
Components in ROS run as nodes. Nodes can be distributed across different computers.

A node might take input and produce output.

Example node:
- rosplan (planning and control)
  - inputs problem data
  - outputs actions
When the whole system is running, there can be a lot of nodes!

Kinect sensor data;
Laser scan;
Odometry;
Transforms;
Velocity commands;
Point cloud data;
Recognised objects;
Octomap data;
PDDL model updates;
PDDL actions;
Action feedback and results;
...
ROSPlan is for controlling a ROS system using a planner.

ROSPlan is a set of nodes which control the system.
- ROSPlan
- input goals, sensor data
- output actions

/rosplan_scene_database

/ROSPlan
/rosplan/notice
/rosplan_planning_system
/rosplan/action_feedback
Main Components of ROSPlan:

- PDDL model (rosplan_knowledge_base)
- planning (rosplan_planning_system)
- MongoDB (rosplan_scene_database)
- Plan dispatch (rosplan_planning_system)
1. **rosplan_knowledge_base** is a node that stores the PDDL domain and problem. The domain is read from file. The problem is generated from sensor data.
2. `rosplan_scene_database` is a node that stores real (non-PDDL) data. For example, coordinates. waypoint0 (PDDL object) -> [0.1, 2.0, 3.4]

(This mongodb_server node is from the ros-indigo-mongodb-store package.)
3. **rosplan_planning_system** is a node that handles top-level control.

- (re)planning
- dispatching plans
The simplest loop is:

```c
while( !goal_reached )
{
  request_problem()
  generate_plan()
  goal_reached = dispatch_plan()
}
```

What are the potential problems with this?

3. `rosplan_planning_system` is a node that handles top-level control.
   - (re)planning
   - dispatching plans
Part of the planning system is the dispatch of plans.

The dispatcher sends PDDL actions as ROS messages to other ROS nodes for execution.

A PDDL plan might look like:

0.000: goto_waypoint ...
1.345: inspect_location ...
2.192: pickup_object ...

How can this be dispatched (robustly)?
ROSPlan stores plans as an Esterel program.

Actions in a plan form nodes in a temporal network. Actions have:
- causal links
- upper and lower constraints on dispatch time
- start, over all, and end conditions (PDDL conditions)

The dispatch of the plan is an interpretation of the Esterel program.

External conditions are checked using queries to rosplan_knowledge_base.

If an action's preconditions were not achieved in time to dispatch it during its time window, then the plan has failed.

What about when an action fails to execute?
External conditions are checked using queries to rosplan_knowledge_base.

Example:

/rosplan_planning_system
External conditions are checked using queries to rospplan_knowledge_base.

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Example:
Back to that top-level loop:

```c
while( !goal_reached )
{
    request_problem()
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    goal_reached = dispatch_plan()
}
```

This won't always work in the real world.

- errors in the PDDL model
- dead-ends
- new discoveries
- the PDDL domain is just not good enough
Back to that top-level loop:

```c
while( !goal_reached )
{
    request_problem()
    generate_plan()
    goal_reached = dispatch_plan()
}
```

Fortunately this is not a fixed behaviour.

The rosplan_planning_system node is activated by a ROS message with:
- conditions
- goals
- timeout constraints

... just like any other action.
Now we will look directly at a ROS system. (Turtlebot 2)
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Setting up ROS to run on multiple computers (and robots)
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How to launch it?
- run a single node.
- launch files for groups of nodes and parameters.
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ROSPlan
- the ROSPlan rqt plugin.
- dispatching single PDDL actions to command the robot.
- sending PDDL goals and letting the robot do what it wants.
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