ROSPLAN TUTORIAL

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"
Proceedings of the 25th International Conference on Automated Planning and Scheduling (ICAPS-15). June 2015.

https://github.com/KCL-Planning/ROSPlan/wiki

ROSPLAN TUTORIAL

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-spacenav-node
rosplan

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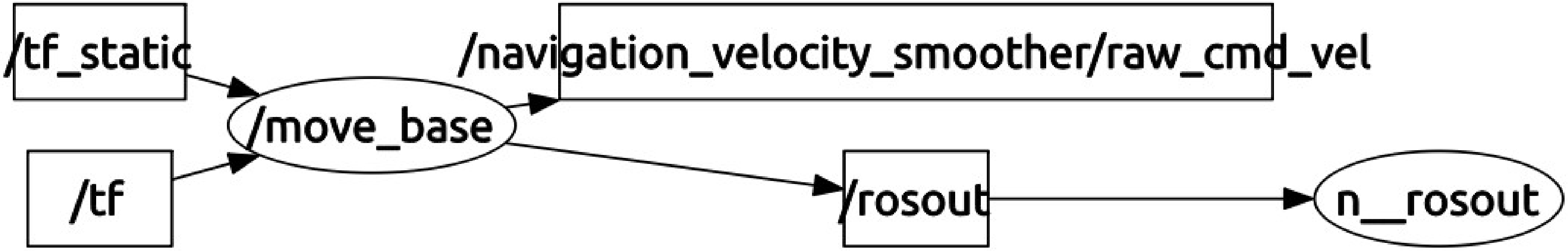
Components in ROS run as nodes. Nodes can be distributed across different computers.

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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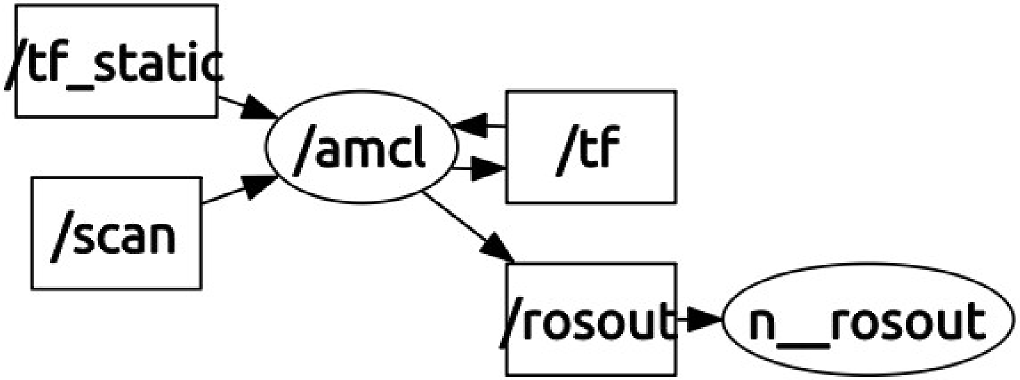
Components in ROS run as nodes. Nodes can be distributed across different computers.

A node might take input and produce output.

Example **node**:

- amcl (odometry)
- - inputs scan data
- - outputs tranform



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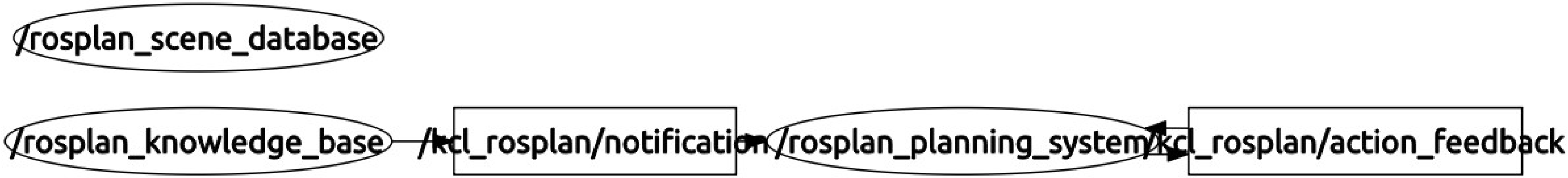
Components in ROS run as nodes. Nodes can be distributed across different computers.

A node might take input and produce output.

Example **node**:

- rosplan (planning and control)
- - inputs problem data
- - outputs actions



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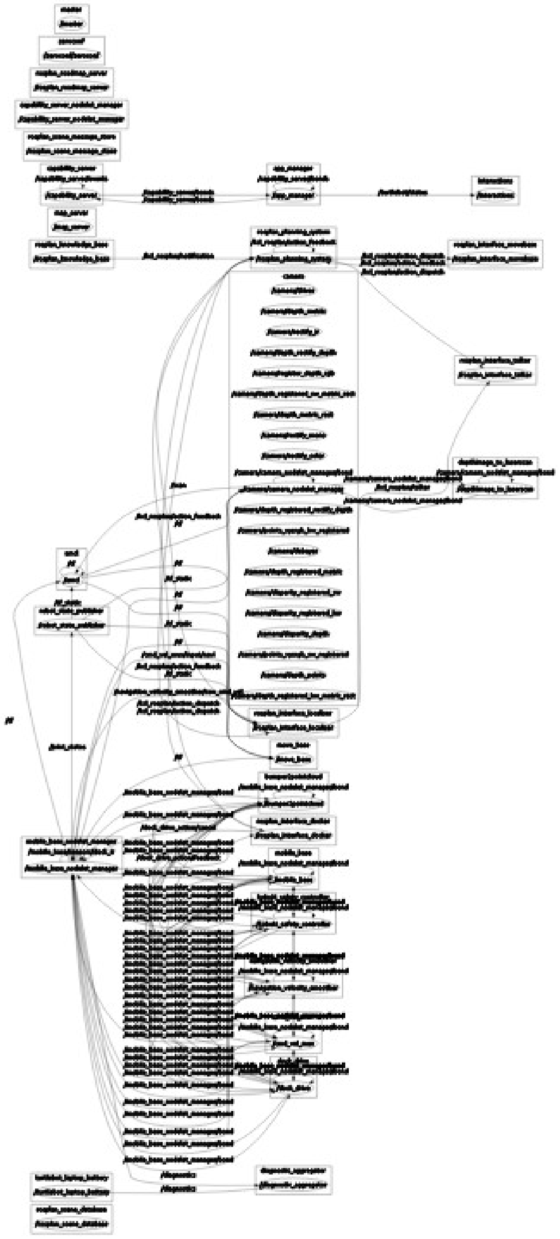
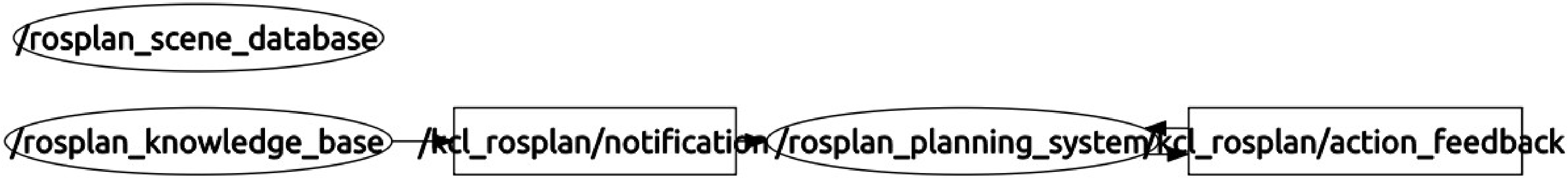
When the whole system is running, there can be a lot of nodes!

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



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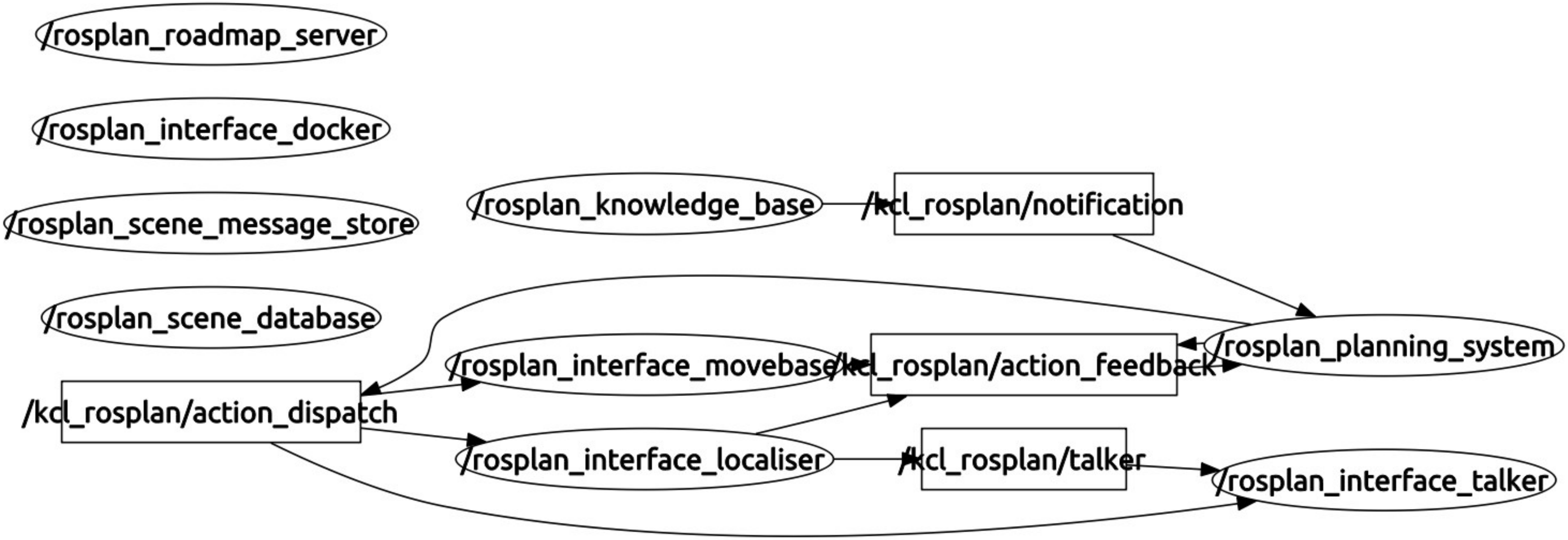
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/rosplan_interface_docker
/rosplan_scene_message_store
/rosplan_scene_database
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/rosplan_knowledge_base
/kcl_rosplan/notification
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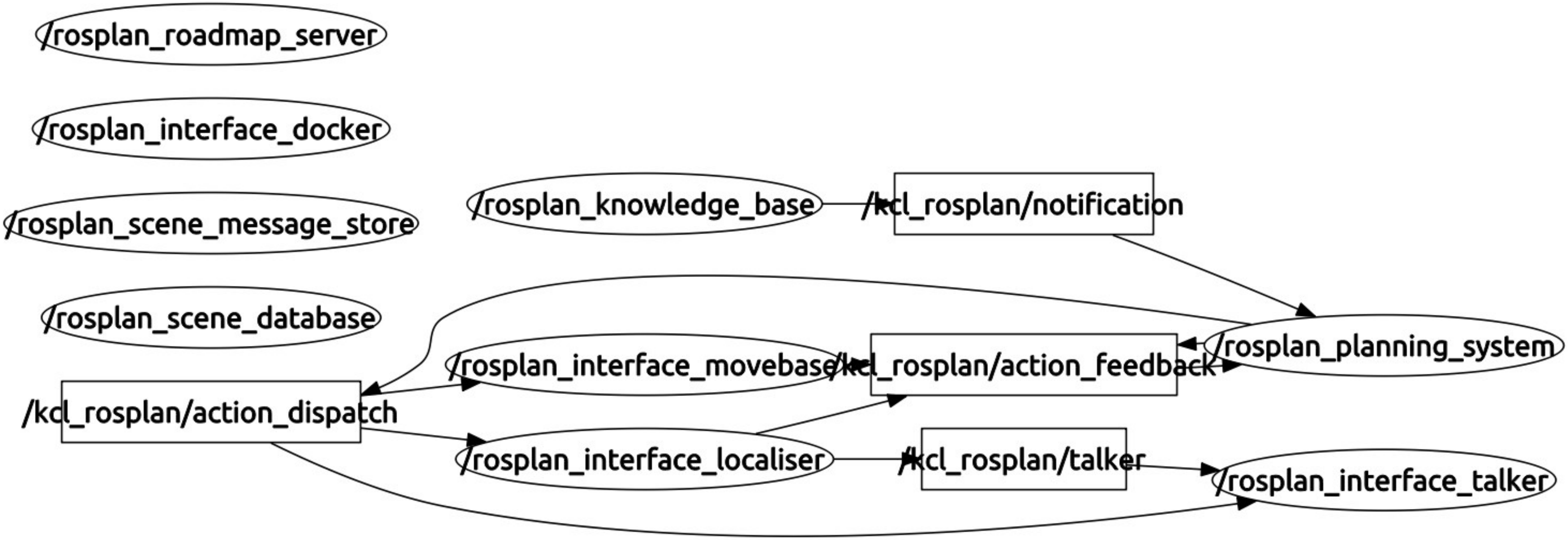
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Main Components of ROSPlan:
- PDDL model (rosplan_knowledge_base)
- planning (rosplan_planning_system)
- MongoDB (rosplan_scene_database)
- Plan dispatch (rosplan_planning_system)

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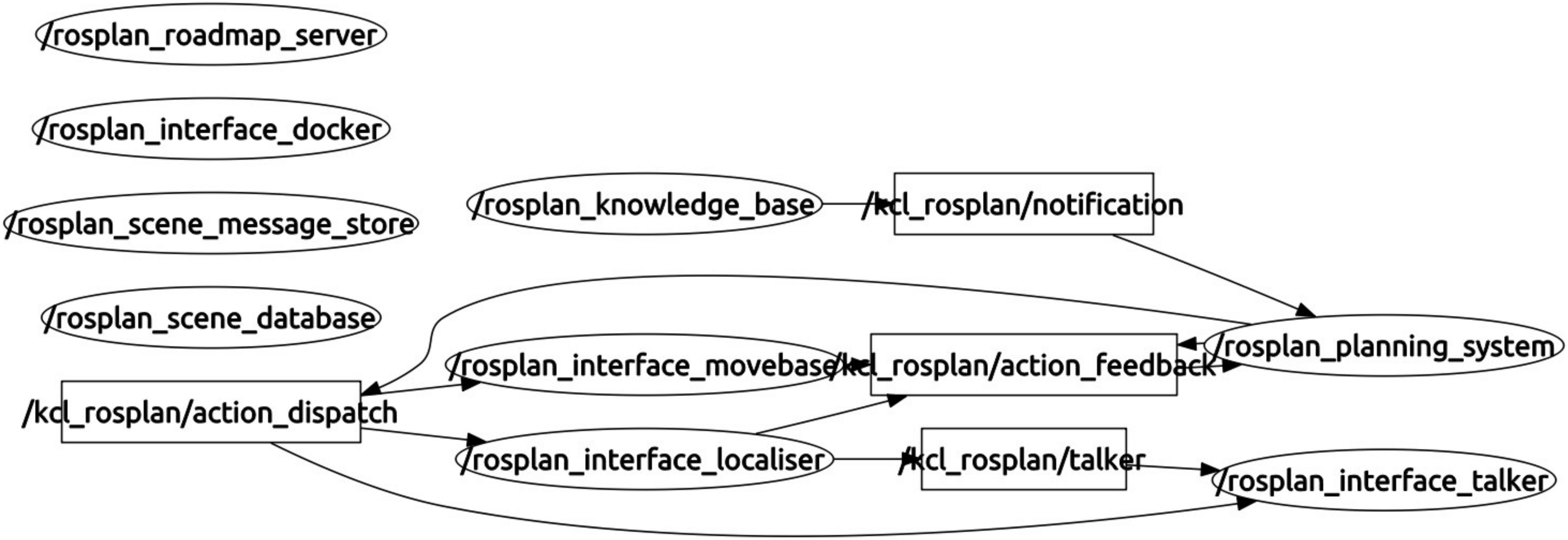
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1.
rosplan_knowledge_base is a node that stores the PDDL domain and problem.
The domain is read from file.
The problem is generated from sensor data.

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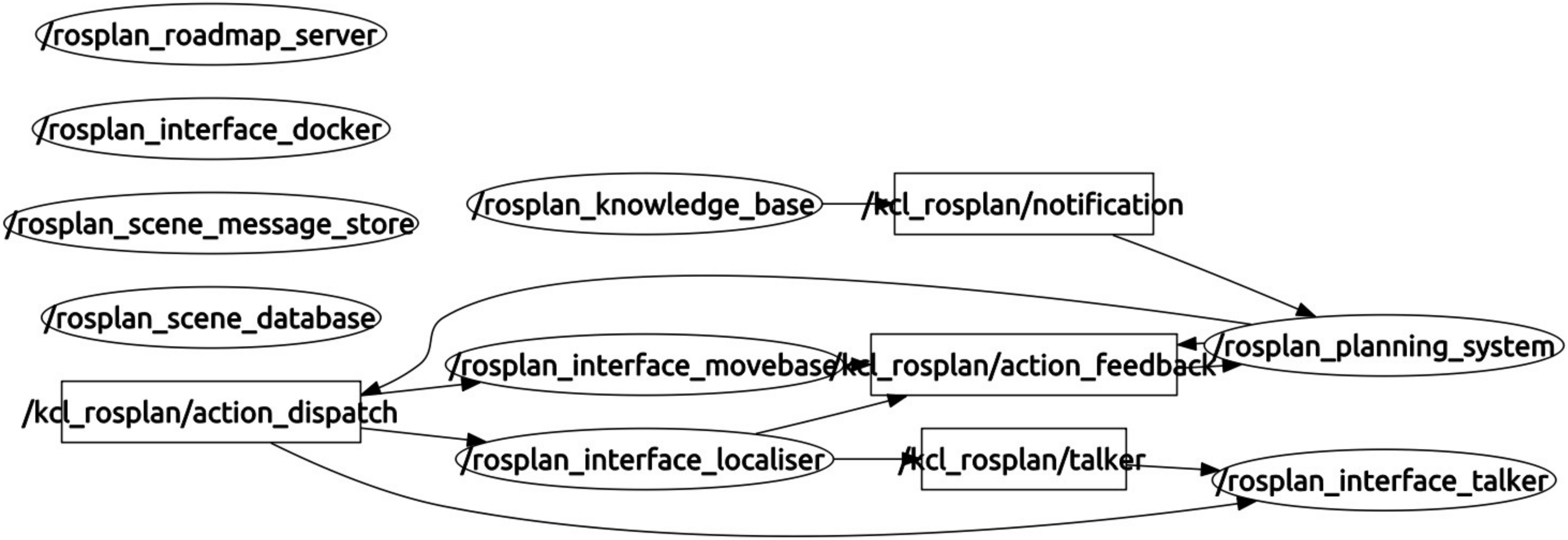
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2.
rosplan_scene_database is a node that stores real (non-PDDL) data.
For example, coordinates.
waypoint0 (PDDL object) -> [0.1, 2.0, 3.4]

(This mongodb_server **node** is from the ros-indigo-mongodb-store **package.**)

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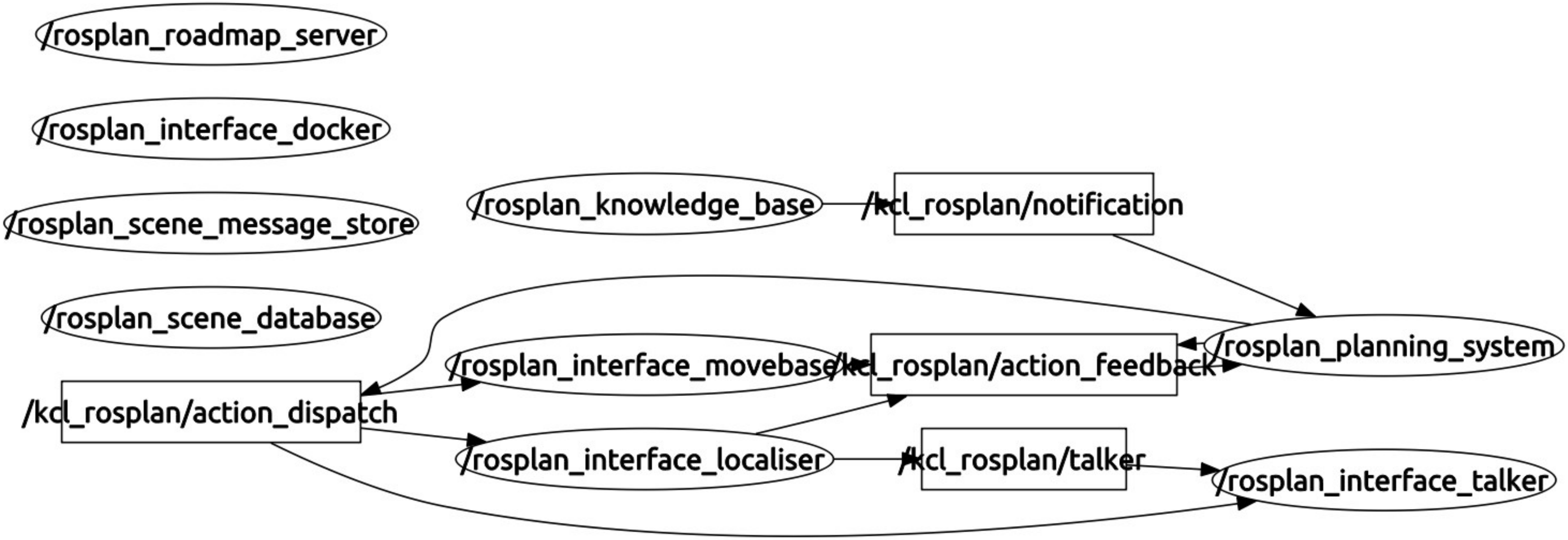

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3.
rosplan_planning_system is a node that handles top-level control.

- (re)planning
- dispatching plans

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- (re)planning
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The simplest loop is:

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

What are the potential problems with this?

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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)?

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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?

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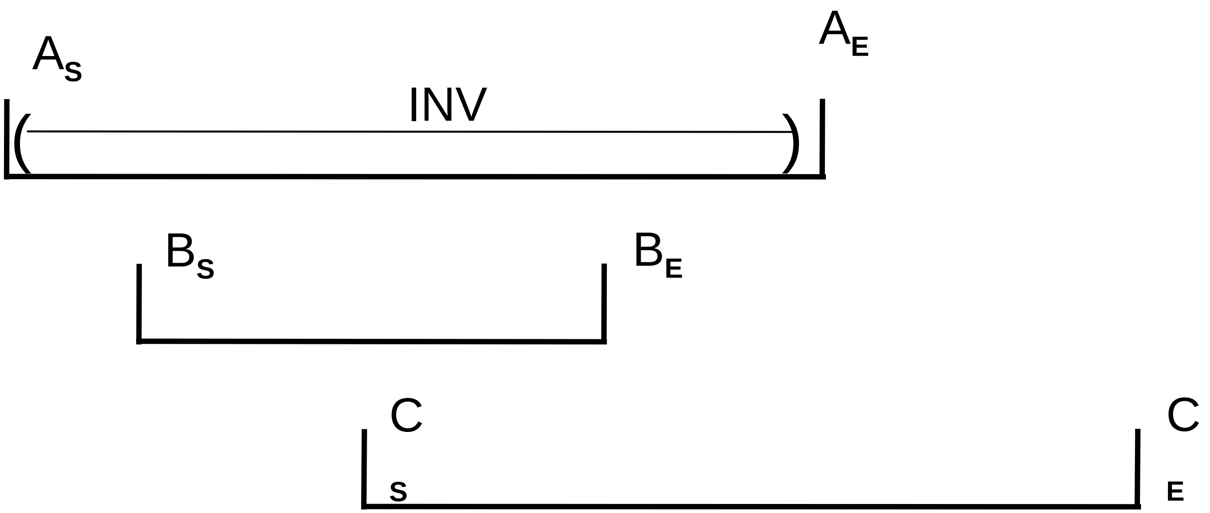
Example:



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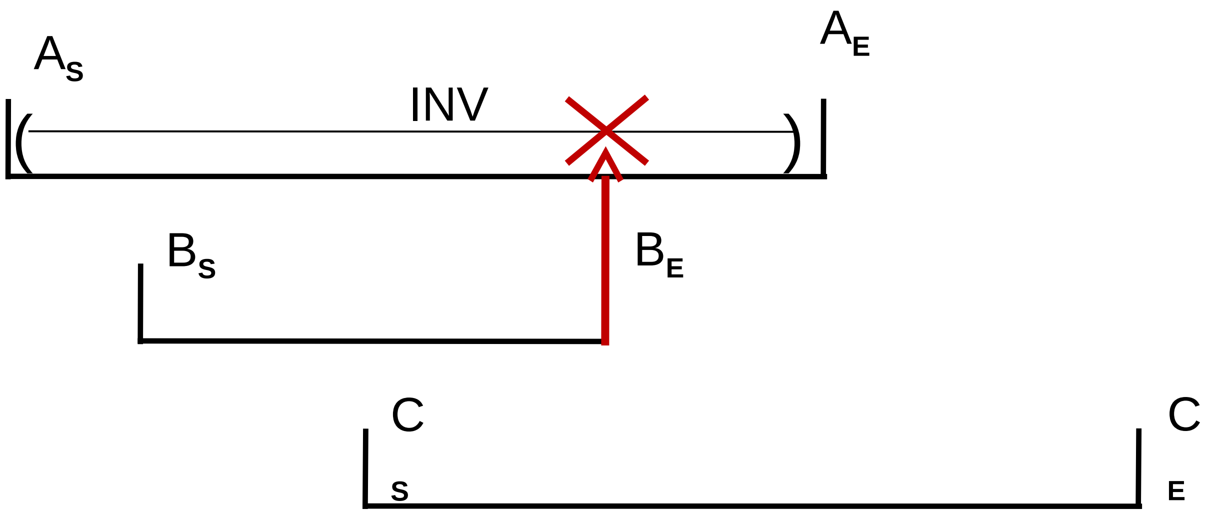

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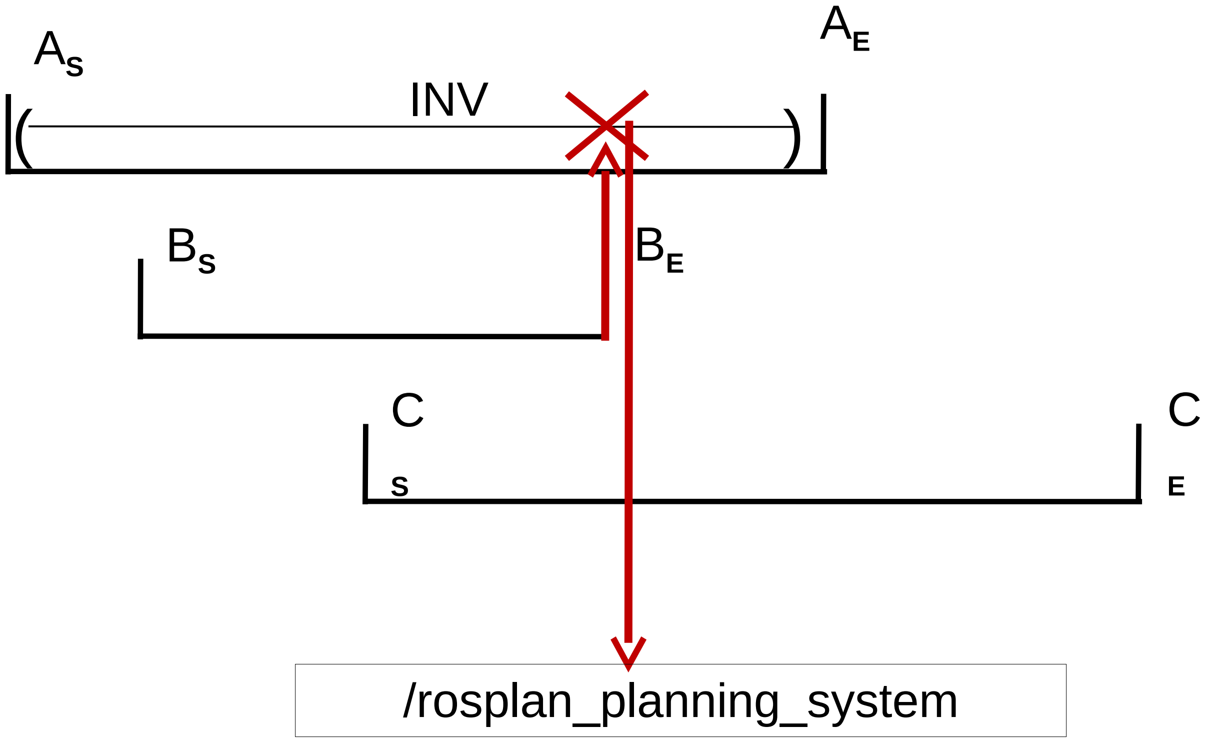

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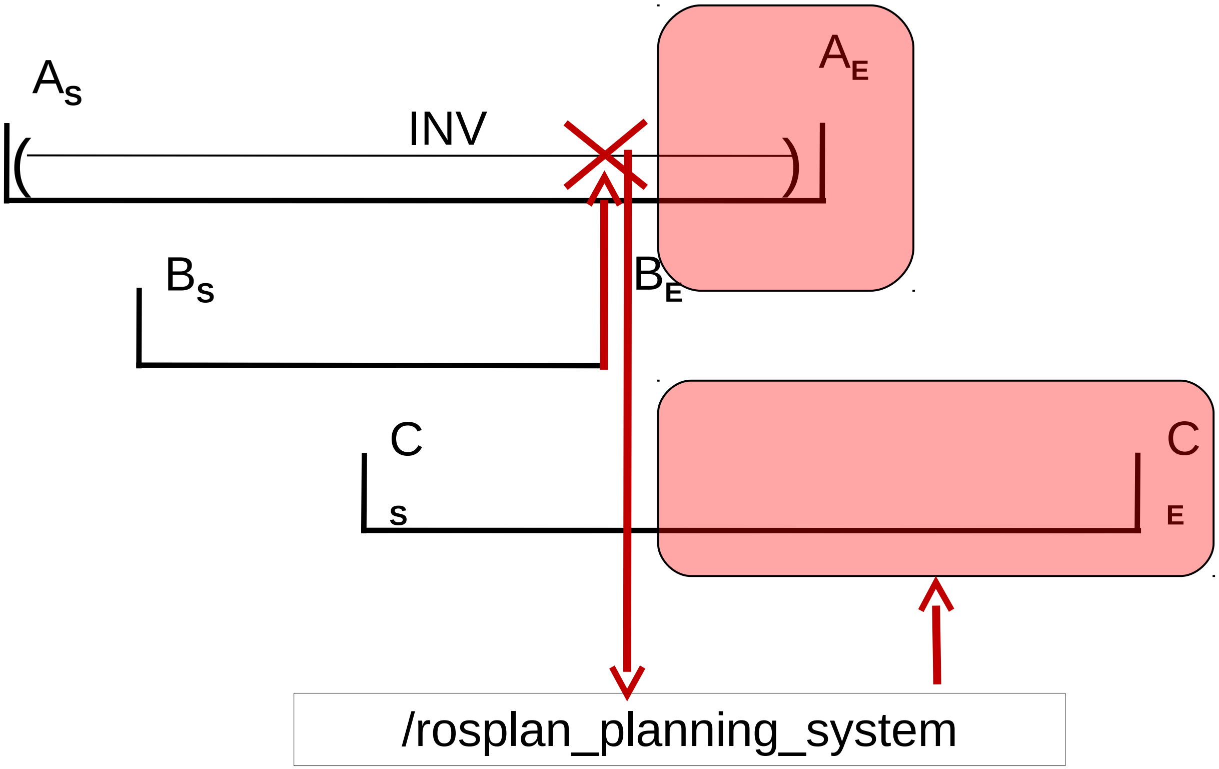

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Back to that top-level loop:

```
while( !goal_reached )
{
    request_problem()
    generate_plan()
    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

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Back to that top-level loop:

```
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.

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Now we will look directly at a ROS system. (Turtlebot 2)

TurtleBot™

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Setting up ROS to run on multiple computers (and robots)

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Setting up ROS to run on multiple computers (and robots)

How to launch it?

- run a single node.
- launch files for groups of nodes and parameters.

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From the command line:
- view nodes.
- view topics and messages.

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Graphical User interfaces
- rviz
- rqt

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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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