

Introduction to Nav2

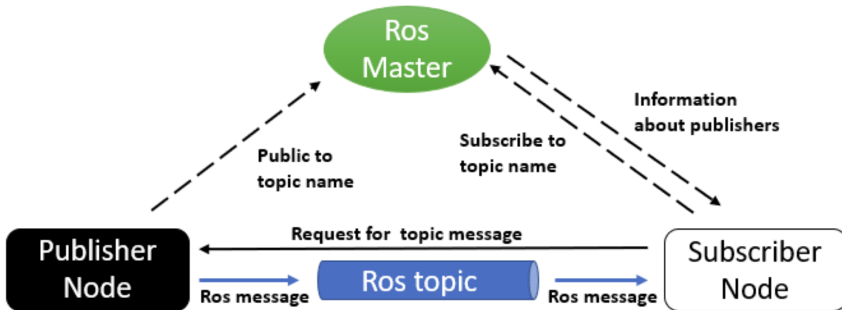


In Robotics, before 2007

- 1 Problem of reusability
- 2 Which standard to follow
- 3 Multiple drivers for the same device, write internal communications, e.g., ICP (Inter-Process Communication), managing of shared data
- 4 Implements the same algorithm in different standards
- 5 Have to start from scratch most of the time

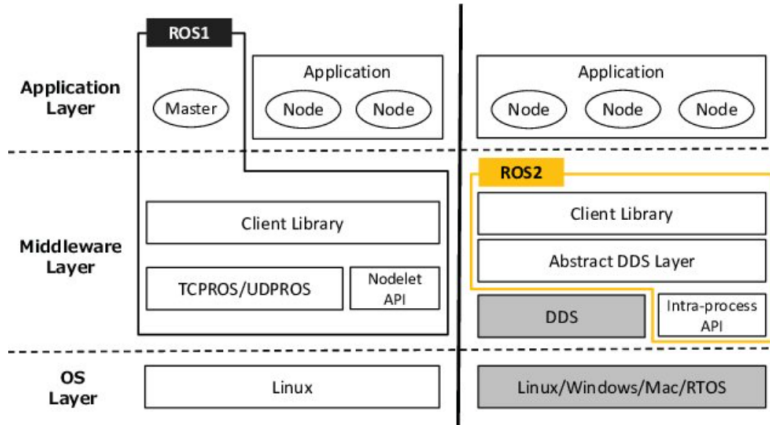


ROS1 Big Picture



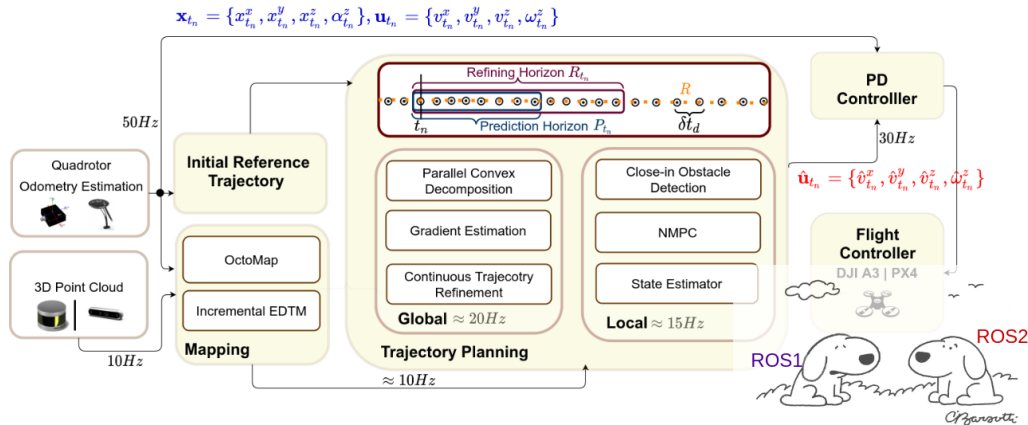
@[https://trojrobert.github.io/hands-on-introduction-to-robot-operating-system\(ros\)/](https://trojrobert.github.io/hands-on-introduction-to-robot-operating-system(ros)/)

ROS2 Big Picture



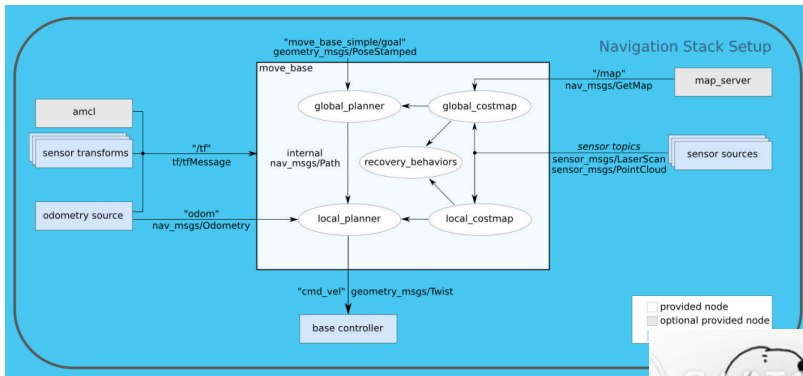
Y. Maruyama, S. Kato and T. Azumi, "Exploring the performance of ROS2," 2016 International Conference on Embedded Software (EMSOFT), Pittsburgh, PA, USA, 2016, pp. 1-10, doi: 10.1145/2968478.2968502.

Why do we need Nav2?



Kulathunga, G., Hamed, H., Devitt, D., Klimchik, A. (2022). Optimization-based trajectory tracking approach for multi-rotor aerial vehicles in unknown environments. IEEE Robotics and Automation Letters, 7(2), 4598-4605.

As a ROS1 developer?



As a ROS2 developer?

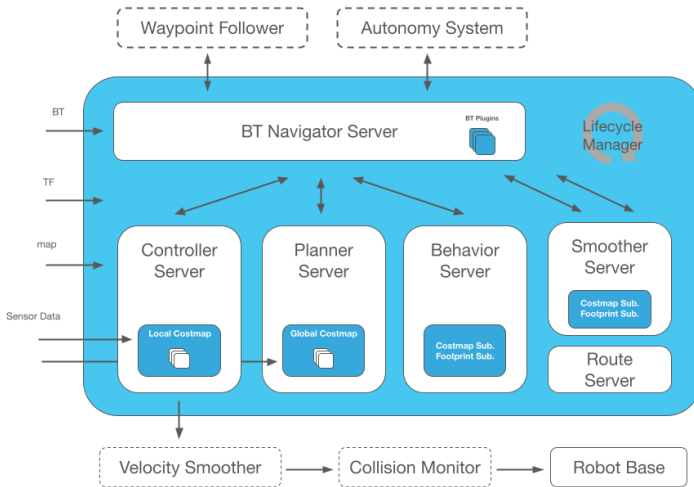


The motivation for Nav2

- **Addresses many of the shortcomings of the ROS 1:** modularity and maintainability
- **Product-ready middleware**
- **Quality and reliability focused**
- **Embedded and real-time support**
- **Multi-agent support** can be used to coordinate the navigation of multiple robots in a coordinated and efficient manner
- **Best security practices** includes a number of security features, such as authentication and authorization, to protect it from unauthorized access and modification

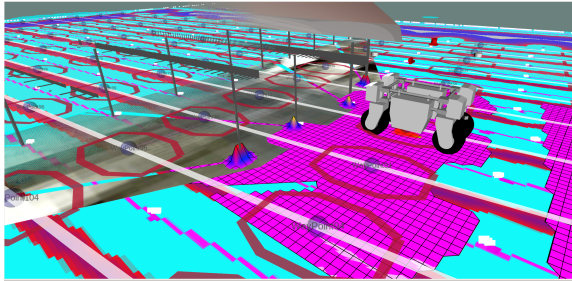
<https://docs.ros.org/en/rolling/Concepts/Intermediate/About-Security.html>

Nav2 Overview

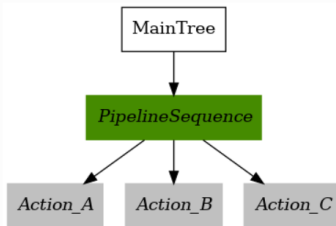


Migrated to ROS2

- Costmap 2D
- AMCL / SLAM Toolbox with some improvement
- NavFn Planner
- Map Server

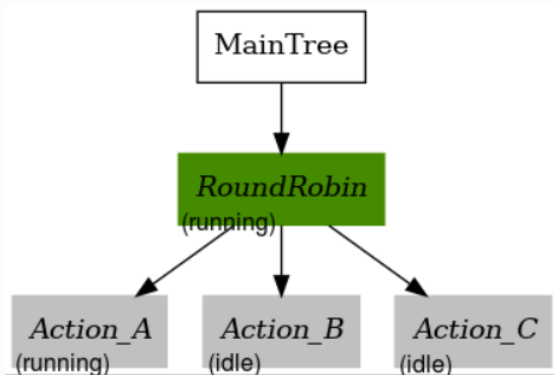


Nav2 Behavior Trees

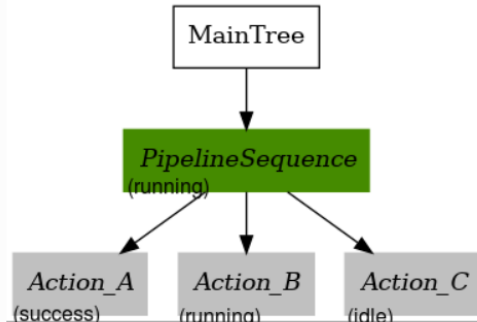


```
<root main_tree_to_execute="MainTree">
  <BehaviorTree ID="MainTree">
    <PipelineSequence>
      <Action_A/>
      <Action_B/>
      <Action_C/>
    </PipelineSequence>
  </BehaviorTree>
</root>
```

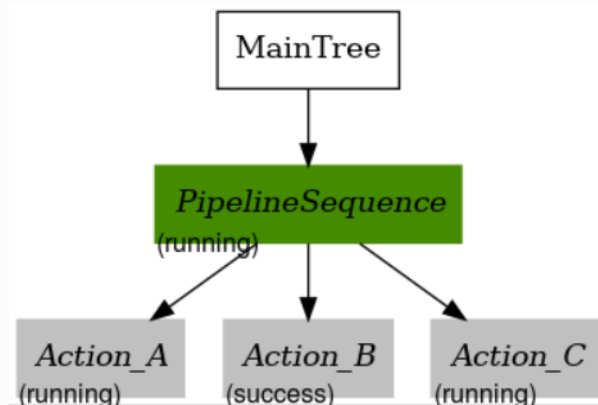
Control: PipelineSequence



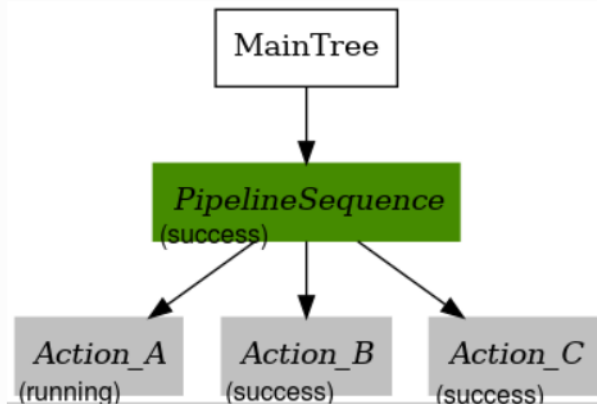
Control: PipelineSequence



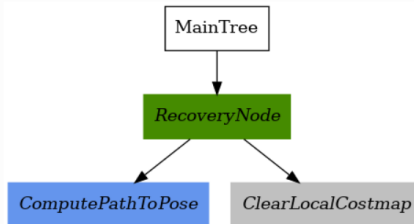
Control: PipelineSequence



Control: PipelineSequence

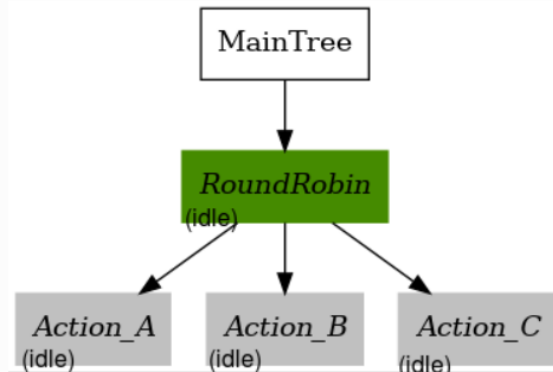


Control: Recovery

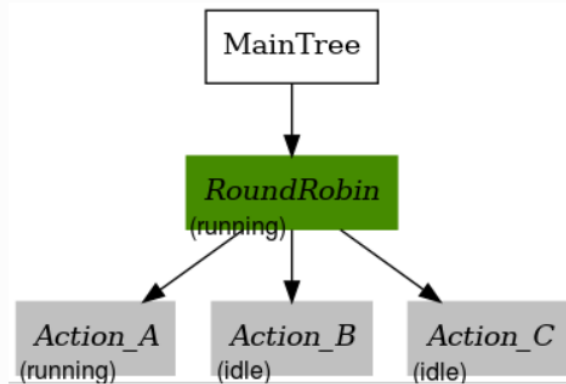


```
<root main_tree_to_execute="MainTree">
  <BehaviorTree ID="MainTree">
    <RecoveryNode number_of_retries="1">
      <ComputePathToPose/>
      <ClearLocalCostmap/>
    </RecoveryNode>
  </BehaviorTree>
</root>
```

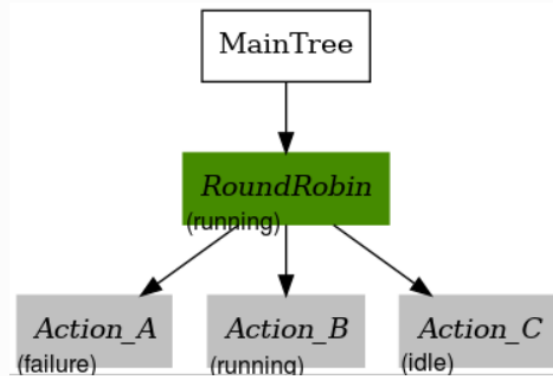

Control: Recovery



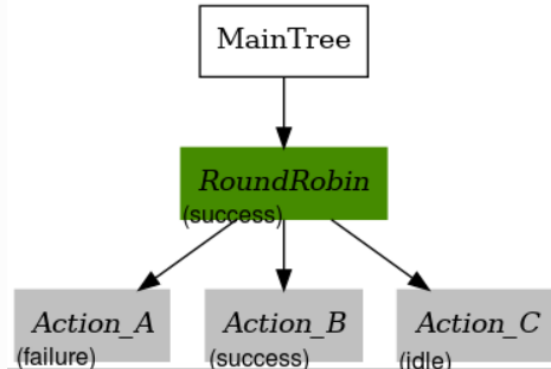
Control: Recovery



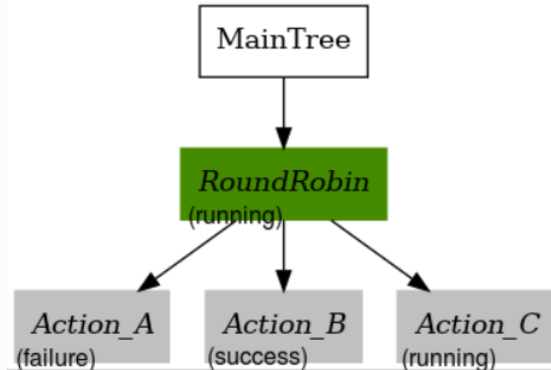
Control: Recovery



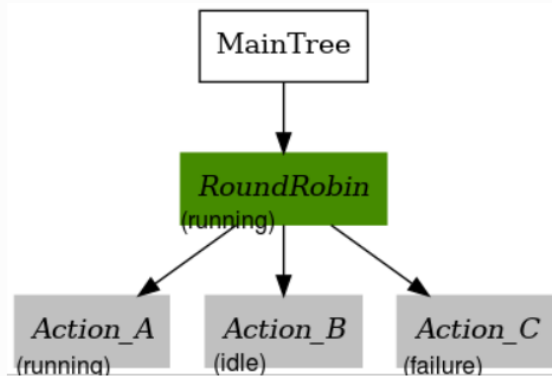
Control: Recovery



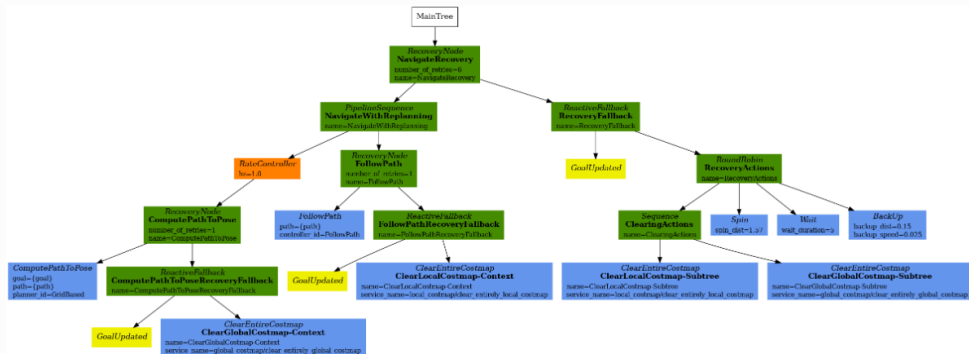
Control: Recovery



Control: Recovery



Navigate To Pose With Replanning and Recovery



New Planning Plugins

Differential

RPP | DWB | TEB

Theta Star
Smac 2D | NavFn
Smac Hybrid
Smac Lattice

Omni

DWB
TEB

Theta Star
Smac 2D
NavFn
Smac Lattice

Ackermann

RPP
TEB

Smac Hybrid
Smac Lattice

Legged

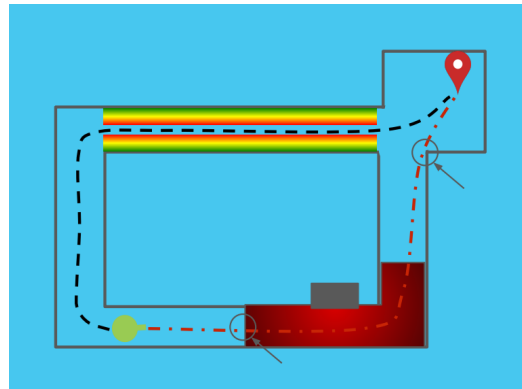
RPP
TEB

Smac Hybrid
Smac Lattice

<https://roscon.ros.org/jp/2021/presentations/8.pdf>

Smac Planner

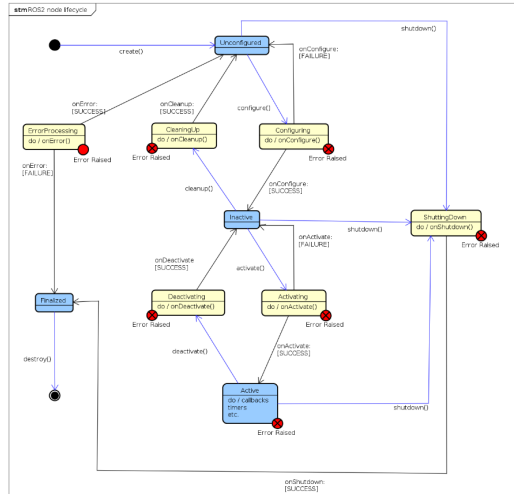
- Cost-Aware Obstacle Heuristic (Steers towards the solution, away from obstacles, Uses cost, not just binary obstacles)
- Search Penalty Functions (Reverse, Change Direction, Non-Straight, Cost)
- Finds exact and feasible paths to the goal



<http://download.ros.org/downloads/roscon/2022/OnUseofNav2SmacPlanners.pdf>

ROS2 Lifecycle Manager

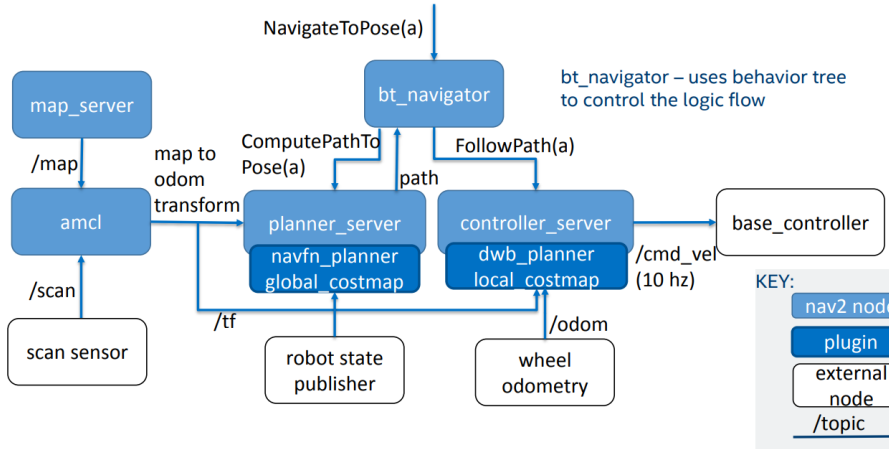
- Allow **roslaunch** to **ensure** that all **components** have been **instantiated correctly** before it **allows any component to begin executing its behaviour**
- Also allow nodes to be restarted or replaced online
- Primary states: **Unconfigured**, **Inactive**, **Active**, **Finalized**
- Transition states: **Configuring**, **CleaningUp**, **ShuttingDown**, **Activating**, **Deactivating**, **ErrorProcessing**



As a ROS2 developer?



As a ROS2 developer?



https://roscon.ros.org/2019/talks/roscon2019_navigation2_overview_final.pdf



"NOW GROWL."