Introduction to Navigation using ROS

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Part of the material in these slides is taken from the Robotics 2 lectures given by G.Grisetti, W.Burgard, C.Stachniss, K.Arras, D. Tipaldi and M.Bennewitz

Outline

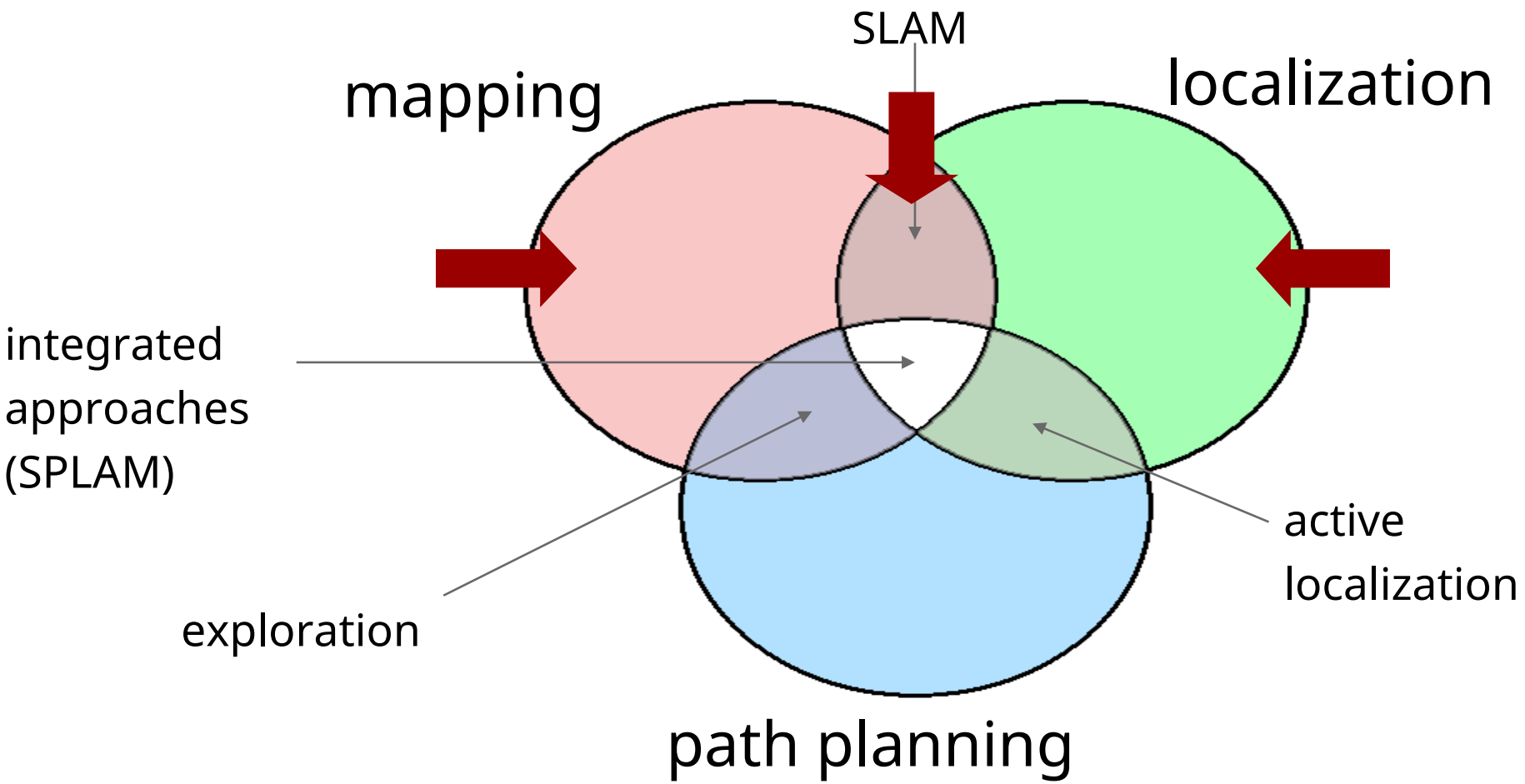
- Navigation Concepts
  - Map, Robot Pose, and Path
  - Taxonomy of Navigation
    - Localization
    - Planning
    - Building a Map
- Building a Map
- Localizing in the map

Sense - Plan - Act

- To **accomplish a task**, a robot should “understand” the environment from it sensor measurements.
- **Understanding**: capturing the information at the right level of abstraction.
- An autonomously navigating robot should know
  - what the **environment** looks like and
  - **where** it is in the environment
  - …

[courtesy of Rainer Kuemmerle and Dirk Heahnel]

What is this Talk about?



[courtesy of Cyrill and Wolfram]

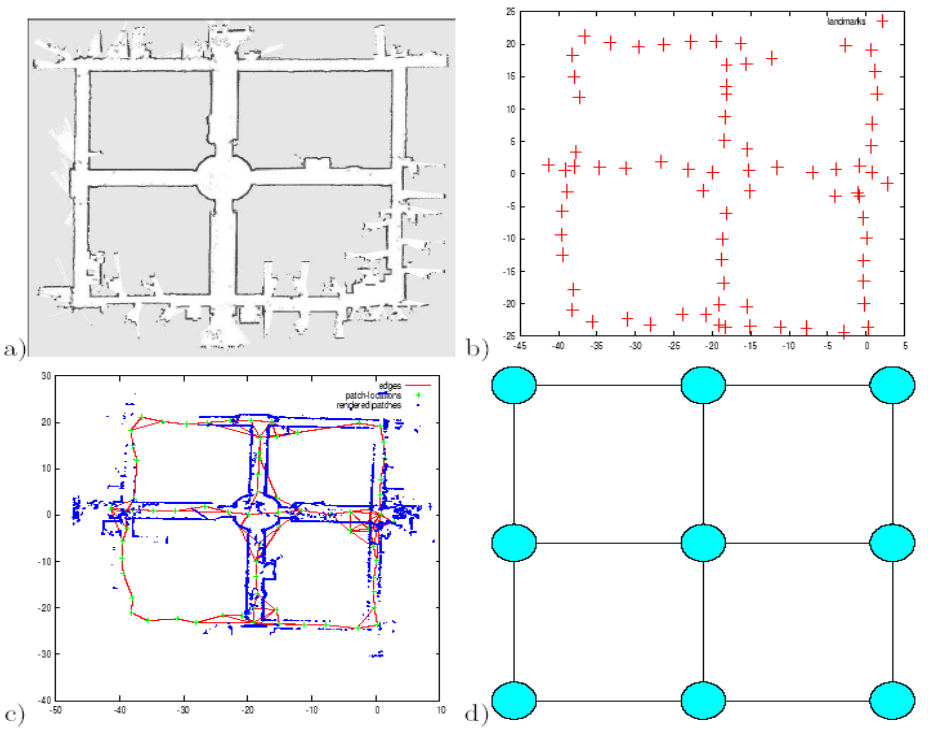
Map

- A map is a representation of the environment where the robot is operating.

- It should contain enough information to accomplish a task of interest.

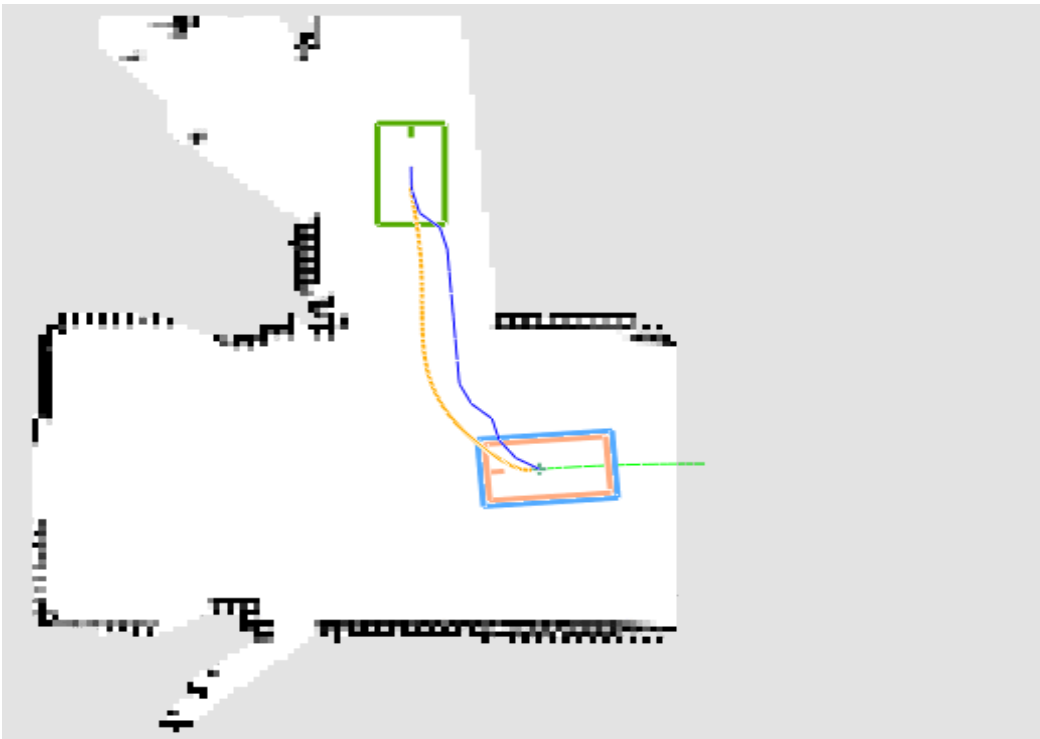
Representations:

- Metric
  - Grid Based
  - Feature Based
  - Hybrid
- Topological
- Hybrid



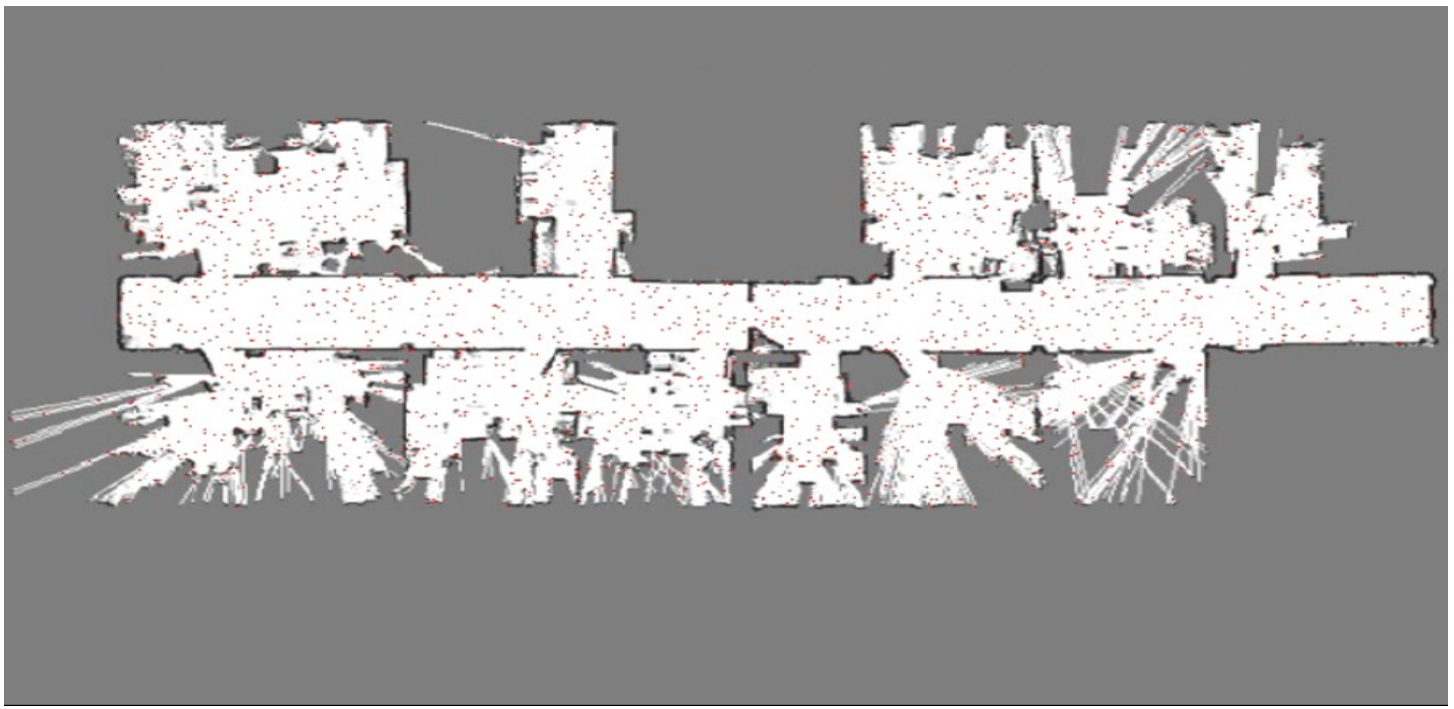
Robot Pose and Path

- A metric map defines a reference frame.
- To operate in a map, a robot should know its position in that reference frame.
- A sequence of waypoints or of actions to reach a goal location in the map is a path.



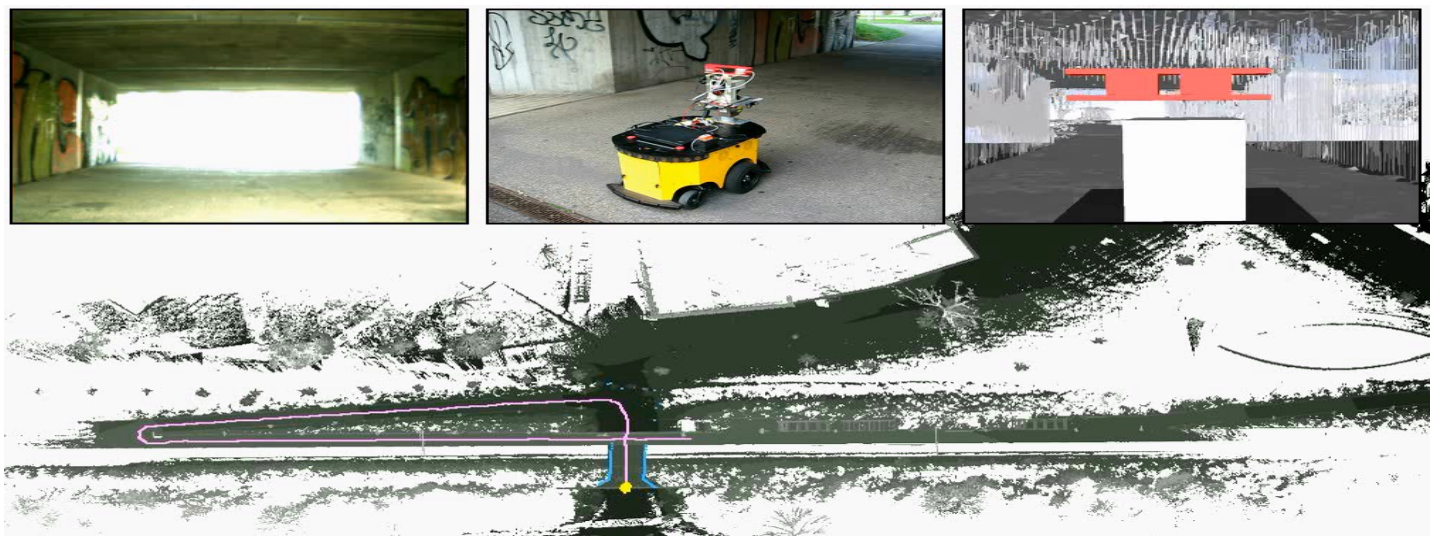
Localization

- Determine the current robot position, using the measurements up to the current instant and a map.



Path Planning

- Determine (if it exists) a path to reach a given goal location given a localized robot and a map of traversable regions.



Mapping

- Given a robot that has a perfect ego-estimate of the position, and a sequence of measurements, determine the map of the environment.
- A perfect estimate of the robot pose is usually not available.
- Instead we solve a more complex problem: Simultaneous Localization and Mapping (SLAM).

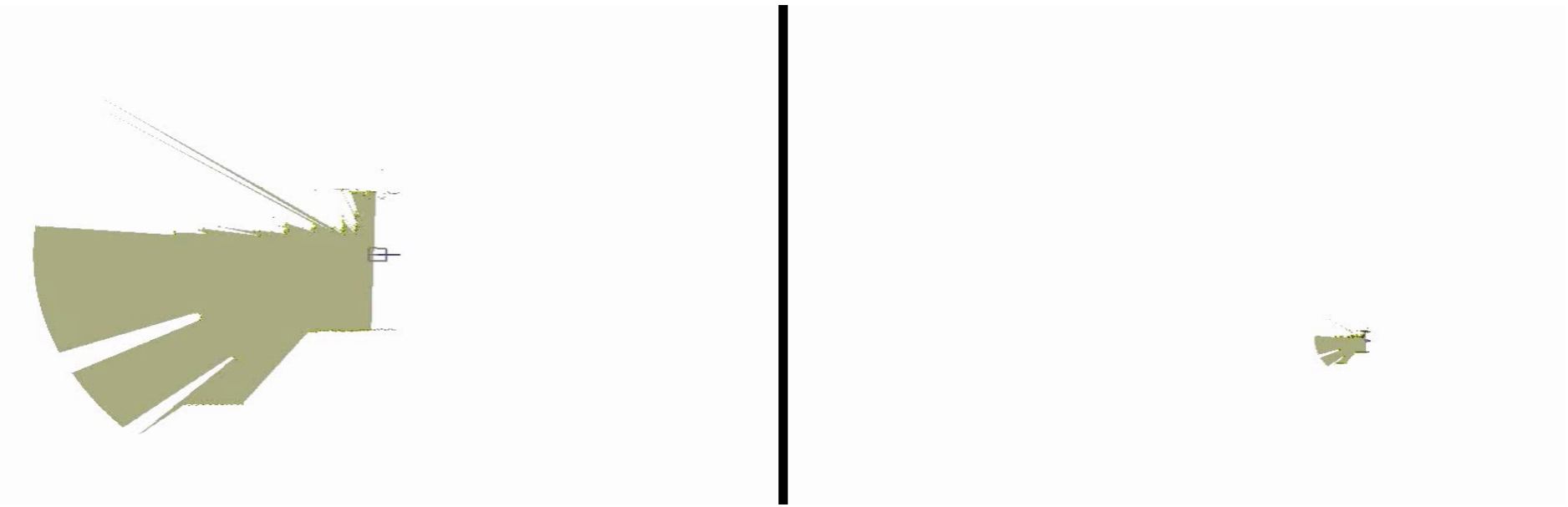
SLAM

- SLAM= Simultaneous Localization and Mapping
- Estimate:
  - the map of the environment
  - the trajectory of a moving device

these quantities are correlated

using a sequence of sensor measurements.

SLAM



Putting Parts Together

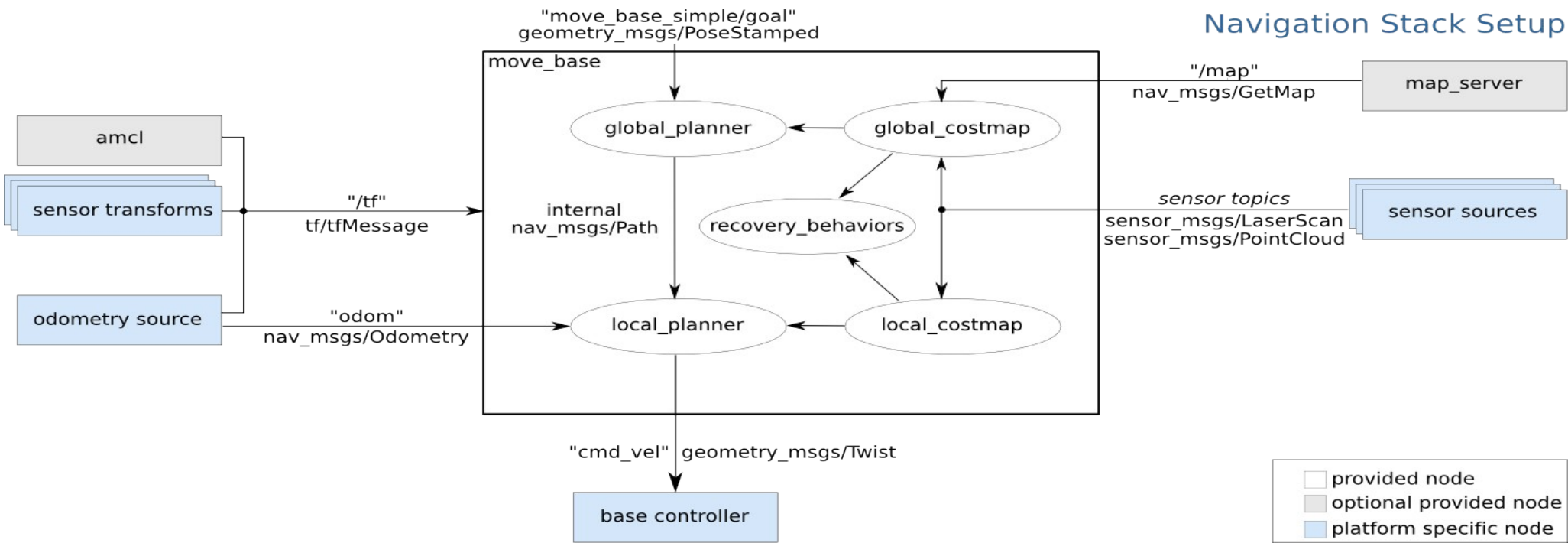
- To navigate a robot we need
  - A map
  - A localization module
  - A path planning module
- These components are sufficient if
  - The map fully reflects the environment
  - The environment is static
  - There are no errors in the estimate

- However
  - The environment changes (e.g. opening/closing doors)
  - It is dynamic (things might appear/disappear from the perception range of the robot)
  - The estimate is “noisy”

  Thus we need to complement our ideal design with other components that address these issues, namely
  - Obstacle-Detection/Avoidance
  - Local Map Refinement, based on the most recent sensor reading.

ROS Navigation Stack

- Map provided by a “Map Server”
- Each module is a node
- Planner has a layered architecture (local and global planner)
- Obstacle sensing refined on-line by appropriate modules (local and global costmap)



Building a Map

- There are gazillions of SLAM algorithms around. ROS by default uses GMapping, which implements a particle filter to track the robot trajectories.
- To build a map you need to
  - Record a bag with /odom, /scan/ and /tf while driving the robot around in the environment it is going to operate in
  - Play the bag and the gmapping-node (see the ros wiki and the live demo), and then save it.
- The map is an occupancy map and it is represented as
  - An image showing the blueprint of the environment
  - A configuration file (yaml) that gives meta information about the map (origin, size of a pixel in real world)

Localizing a Robot

- ROS standard navigation stack implements the Adaptive Monte Carlo Localization algorithm
  - AMCL uses a particle filter to track the position of the robot (see paper of Fox et al.)
  - Each pose is represented by a particle.
  - Particles are
    - Moved according to (relative) movement measured by the odometry
    - Suppressed/replicated based on how well the laser scan fits the map, given the position of the particle.
- The localization is integrated in ROS by emitting a transform from a map-frame to the odom frame that “corrects” the odometry.
- To query the robot position according to the localization you should ask the transform of base_footprint in the map frame.

Setting up a navigation Stack

Refer to the navigation tutorial

http://wiki.ros.org/navigation/Tutorials

In the practical:

- Recording data
- Building a map
- Starting localization
- Issue position commands