



**Hochschule  
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University of Applied Sciences

# Software Development Project

Final Presentation

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# Introduction

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# Software Development Project

- Object-oriented software development
- Agile software development
- Unified modeling language (UML)
- Refactoring
- Software development in robotics

# Basic Navigation Test

- Environment: Workspaces, waypoints and obstacles.
- Task specification: Sequence of poses.



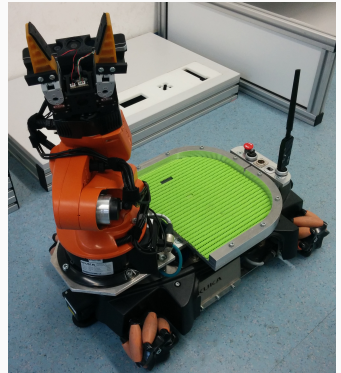
# Challenges

- **Perception:** Accessing and processing sensor data.
- **Mapping:** Building map of the environment.
- **Localization:** Pose inside map.
- **Path planning:** Determine sequence of poses between waypoints.
- **Motion control:** Execution of path.

# KUKA youBot

The youBot is a mobile manipulator designed for education and research purposes. It comes with fully open interfaces and API.

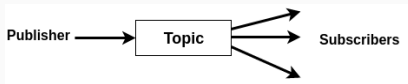
- Omnidirectional, four-wheeled
- 5-DOF manipulator with a two-finger gripper
- On-board PC with CPU, 2GB memory, 32GB SSD drive
- Sensors: vision sensors, rangefinders



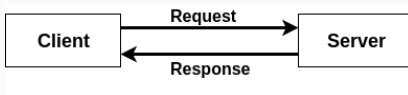
# Robot Operating System (ROS)

Set of software and libraries.

- **Node:** A process using ROS.
- **Topic:** Message queue, used for communication between nodes.



- **Service:** Offers synchronous service calls.



- **Actionlib**

- Provides client interface to send requests to server
- Client and server communicate with messages:
  - Goal
  - Feedback
  - Result



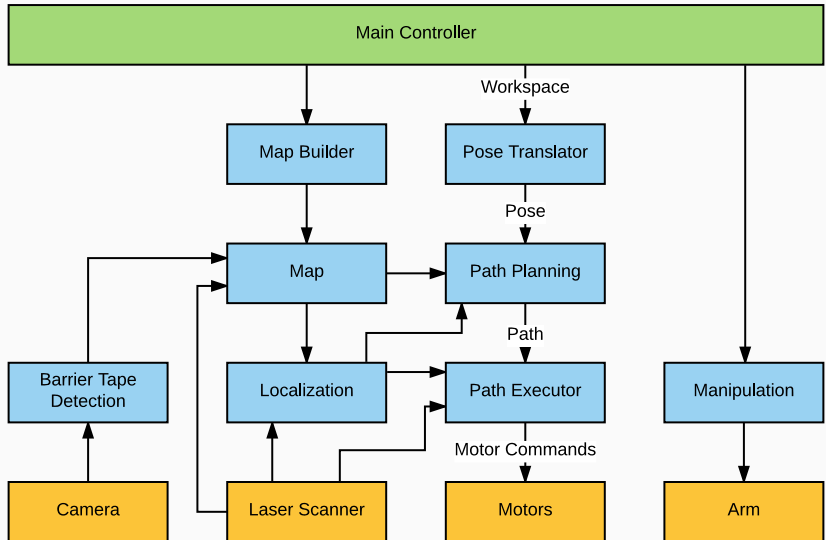
# Approach

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# Approach

- Divide problem into smaller parts.
- Each part is defined by
  - It's function and
  - Interface
- Parts are replaceable.

# Software Modules

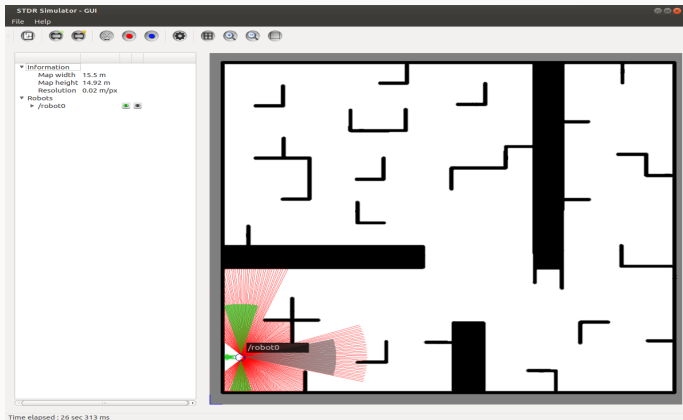


# Realization

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# Simulation

- Simple Two Dimensional Robot (STDR) simulator
- Tasks performed:
  - Map Building
  - Localization



# Map building I

- Gmapping is used to build 2D occupancy grid map
- Map Server
  - Provides map saver utility, to save generated map in files(yaml and pgm)
  - Offers map data as a ROS Service

- Adaptive Monte Carlo Localization (AMCL) is used to localize the robot
- Uses particle filter to track the pose of robot
- What it needs?
  - Laser scans
  - Initial pose
  - Transforms
  - Map

- **Problems**

- Amcl could not find laser data on /scan topic
- Amcl node crashes after some time

- **Solutions**

- Remap /scan\_front and /scan\_rear to /scan topic
- Because of incorrect transformations provided by stdr simulator



- **ROS Wrapper**

- Allows to write ROS programs for controlling youBot
- Provides an interface between youBot driver and ROS framework
- Allows to move the base and arm by sending ROS messages

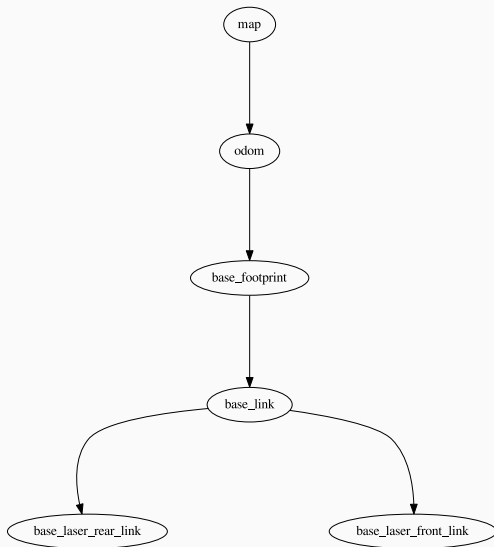
- **List of Drivers**

- Drive base
- Laser scanners
- Arm
- Joystick
- Transformations

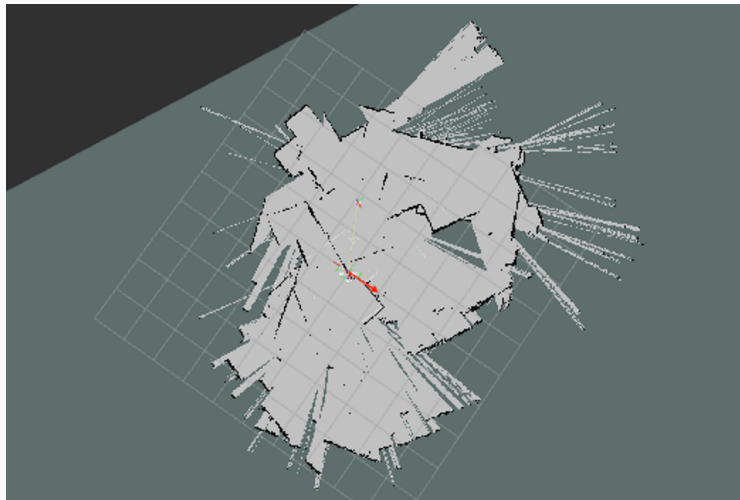
# Map building II

- **Problems**
  - Messy Map
- **Solutions**
  - Incorrect transformation between laser frame and base link

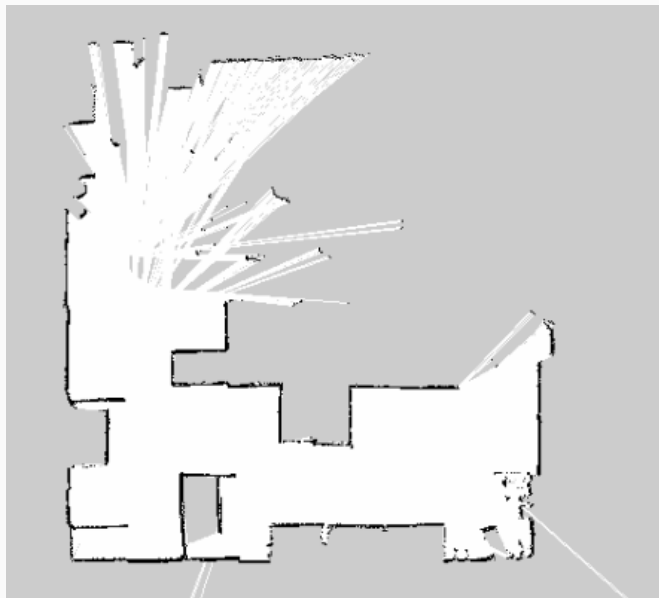
# Map building II



## Map building III



## Map building IV



- **Problems**

- Amcl is not working
- Amcl cannot localize robot when it is in the end of arena

- **Solutions**

- Parameter `odom_model_type` should be `omnicorrected`
- Arena was changed a lot, so sensor reading cannot be related to map

# Navigation

- Requirements
  - Map (map\_server)
  - Localization (amcl)
  - Odometry source
  - Transforms
  - Sensor sources
  - Goal (move\_base)
- Components
  - Planners: global, local
  - Costmaps: global, local
- Output: Velocity command (cmd\_vel)

# Navigation - Local Planner

- Planner: `dwa_local_planner`
- Given: plan, costmap, odom
- Generates costs of transversing through map grids
- Output: Velocity command



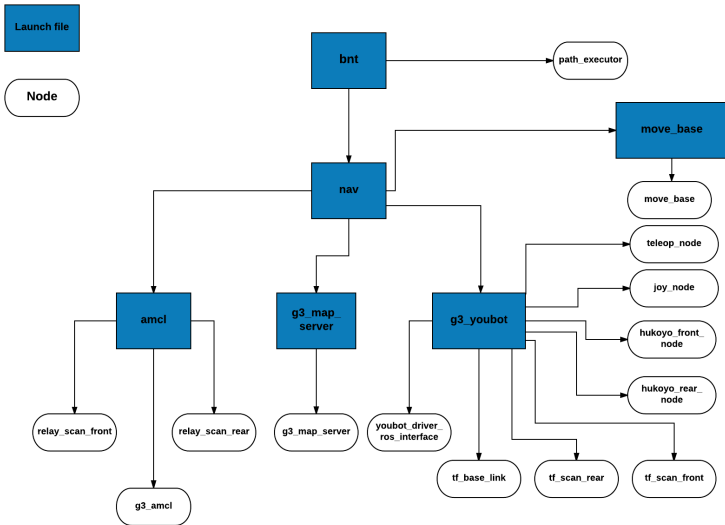
The node acts as path executor that reads a set of user inputs and convert them to move\_base\_msgs.

- Class: Position, Pose, Environment, Workspace, PathExecutor
- Functions:
  - Reads user inputs
  - Reads workspace from file
  - Converts workspace to move\_base\_msgs
  - Clears cost map
  - Sends goal message

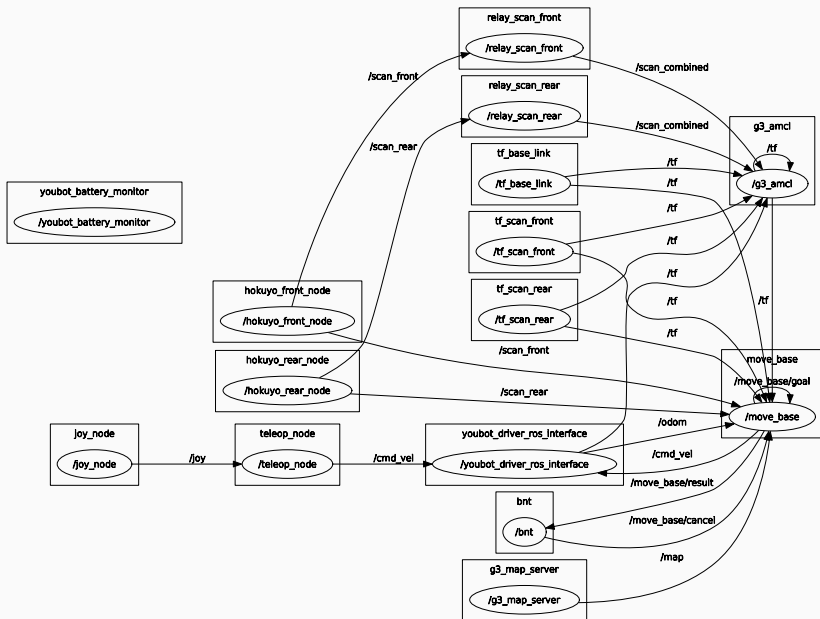
# Results

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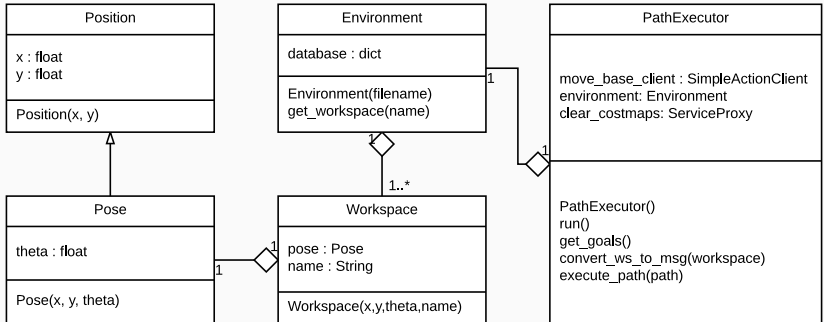
# Launch Files



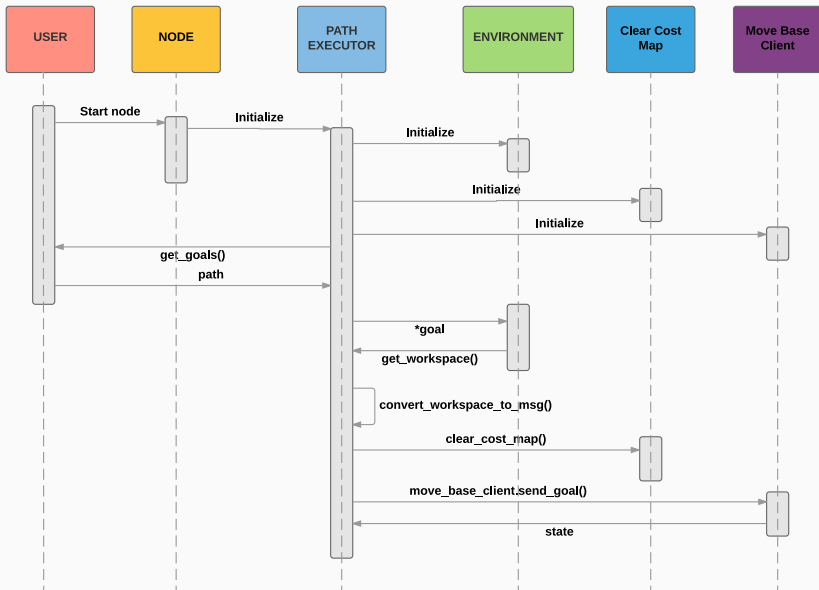
# RQT Graph



# Class Diagram



# Sequence Diagram



# Conclusions

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# Conclusions

- ROS is a powerful and flexible framework for robot software development.
- Navigation was analyzed and applied to youBot.
- The task contains mapping, localization, path planning, motion execution.
- Mapping and localization were realized in simulation, while all the subtasks were executed on youBot in experiments.
- The subtasks were successively carried out, such that navigation of robot was resolved.
- The robot was able to navigate around the lab by user input of a series of workspace.



# Future Work

- User interface can be improved.
- Enable the robot to detect barrier tapes.
- The parameters can be retuned to improve the performace of robot.