EMC 2014
Software Design

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Eindhoven University of Technology

Department of Mechanical Engineering

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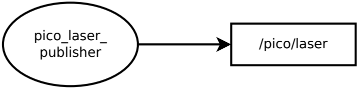
ROS Communication Example

pico_laser_
publisher

ROS Communication Example



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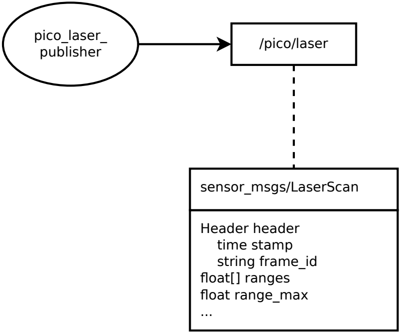
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sensor_msgs/LaserScan

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    string frame_id
float[] ranges
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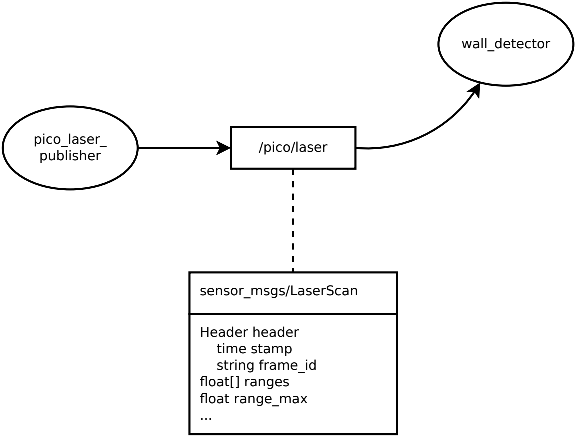

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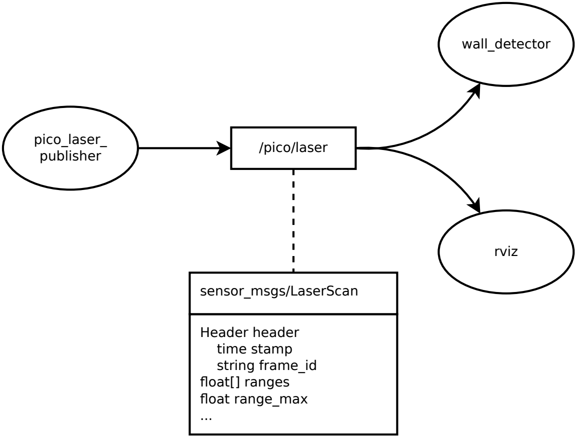

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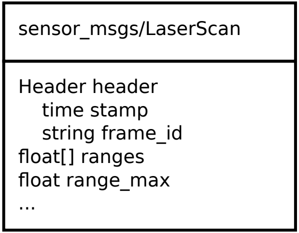

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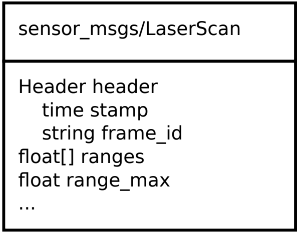

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    Header header;
    float range_max;
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}

struct Header {
    std::string frame_id;
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}

struct Time {
    int secs;
    int nsecs;
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- This function is called every time the node receives a message:

```
void callbackFunction(sensor_msgs::LaserScan scan) {
    // do something
    std::cout << scan.header.stamp << std::endl;
}
```

PICO Safe Drive

PICO Safe Drive

```
// Include ROS framework (Publishers, Subcribers, init, etc)
#include <ros/ros.h>

// Include the LaserScan message type
#include <sensor_msgs/LaserScan.h>

// Include the Twist message type (used for sending velocity
  commands to the base)
#include <geometry_msgs/Twist.h>

// Global variables
bool drive = true;
ros::Publisher cmd_pub;
```

PICO Safe Drive

```
int main(int argc, char** argv) {
// Register your ROS node
ros::init(argc, argv, "pico_safe_drive");

// Create node handle
ros::NodeHandle n;

// Subscribe to topic '/pico/laser' topic
ros::Subscriber sub = n.subscribe("/pico/laser",1,laserCallback);

// Create 'cmd_vel' publisher
cmd_pub = n.advertise<geometry_msgs::Twist>("/pico/cmd_vel", 10);

// Program loop
while (ros::ok()) {
    ros::spinOnce(); // Check incoming messages
    sendVelocity();  // Publish velocity
    ros::Duration(0.1).sleep(); // Sleep 0.1 seconds
}

return 0;
```

PICO Safe Drive

```
void laserCallback(sensor_msgs::LaserScan scan) {

    // Default: drive
    drive = true;

    // Check all laser points
    for(unsigned int i = 0; i < scan.ranges.size(); i++) {
        // Check laser point distance
        if (scan.ranges[i] > 0.1 && scan.ranges[i] < 0.3) {
            // Oh no, something is near! Better stop driving...
            drive = false;
        }
    }
}
```

PICO Safe Drive

```
void sendVelocity() {
    // Create a ROS Twist message
    geometry_msgs::Twist cmd_msg;

    // Set forward velocity
    if (drive) {
        cmd_msg.linear.x = 0.2;
    } else {
        cmd_msg.linear.x = 0;
    }

    // Set all the other components to 0
    cmd_msg.linear.y = 0;
    cmd_msg.linear.z = 0;

    cmd_msg.angular.x = 0;
    cmd_msg.angular.y = 0;
    cmd_msg.angular.z = 0;

    // Send the command!
    cmd_pub.publish(cmd_msg);
}
```

Safe_drive Example

/pico/laser
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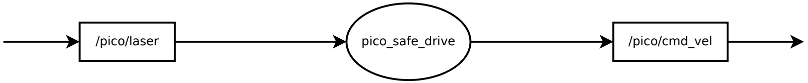

System Input / Output

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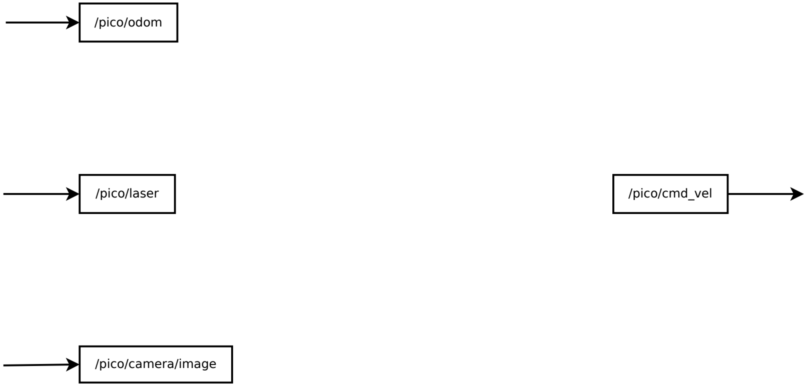

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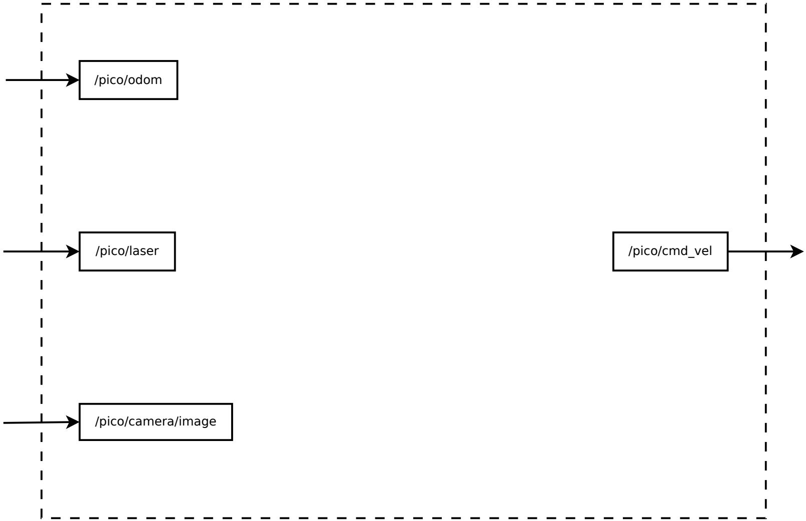
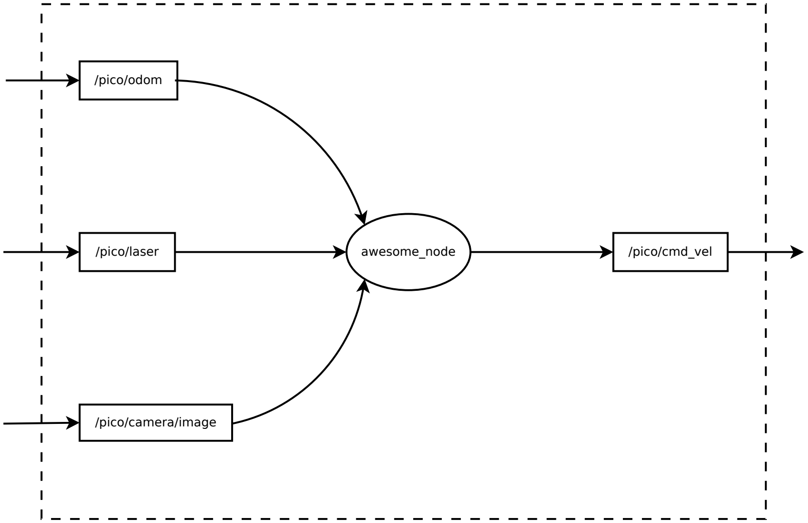


Black Box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  - Hard to maintain
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  - Hard to extend:
    - Adding new features may break old ones
  - Teamwork becomes hard:
    - No clear division of work
    - Practical example: all editing the same file

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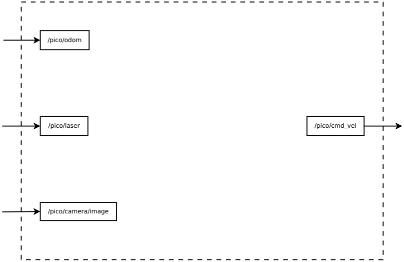
  - Encapsulation of functionality and data
    - Easier to predict behavior
    - Easier to find errors
    - Easier to add new functionality

Identify Goal



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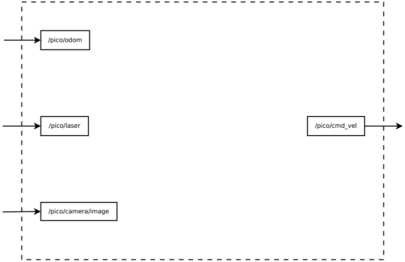

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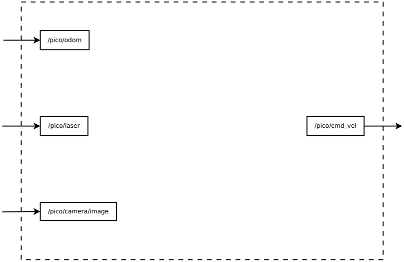

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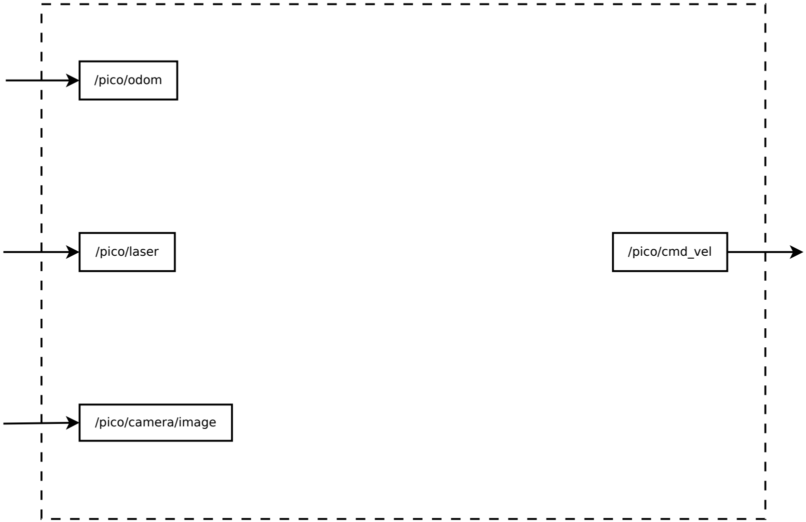

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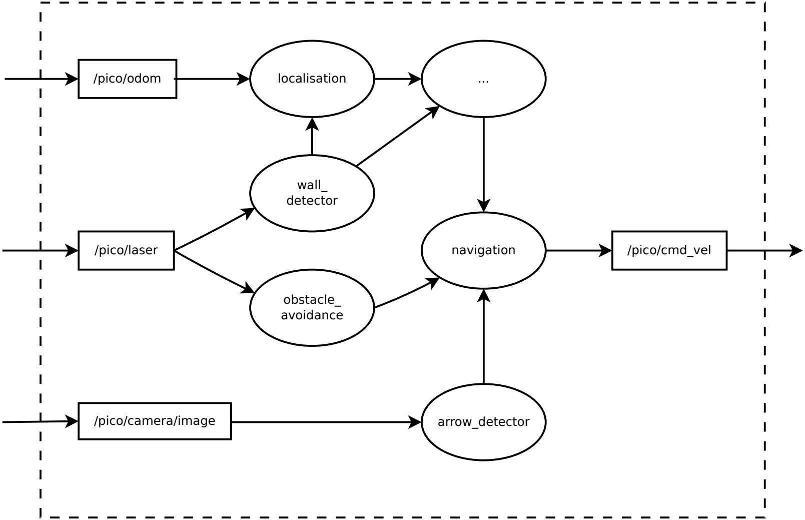

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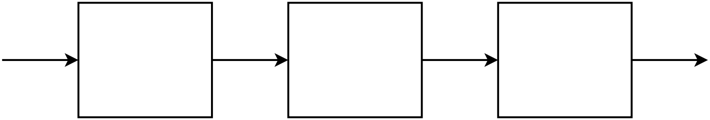

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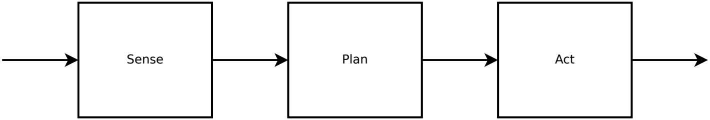

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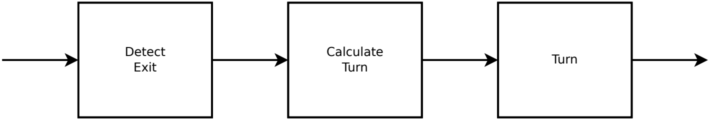

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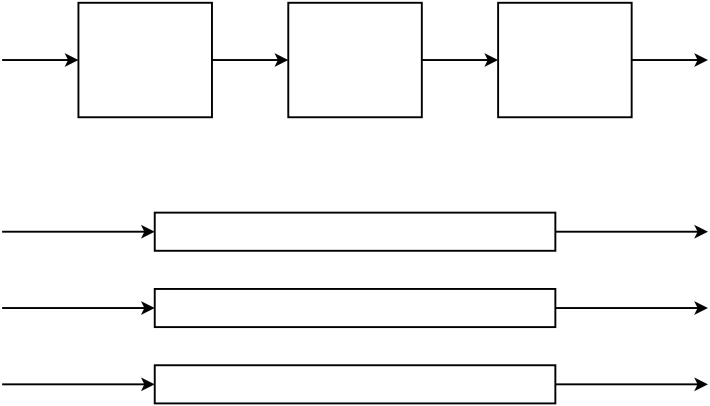

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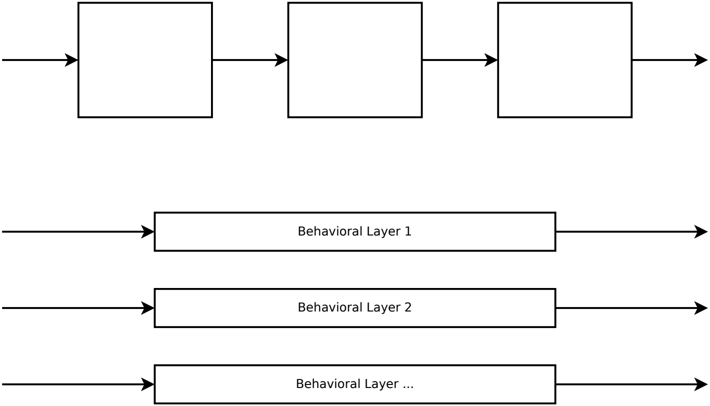

Behavioral Layer 1

Behavioral Layer 2

Behavioral Layer ...

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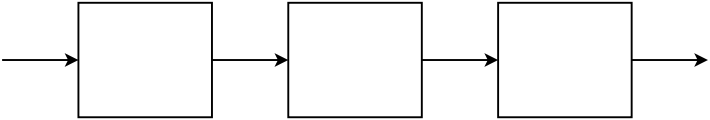

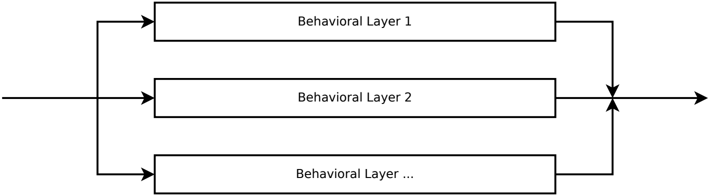

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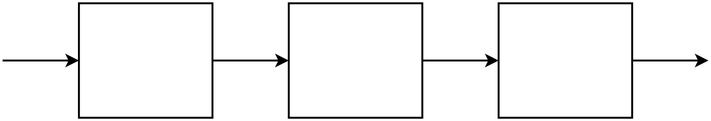

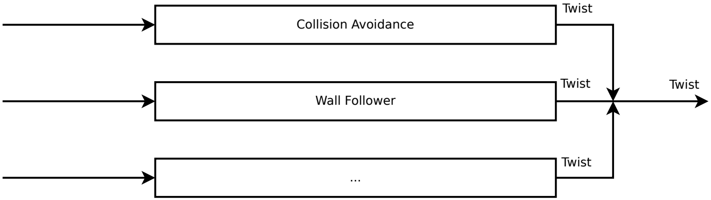

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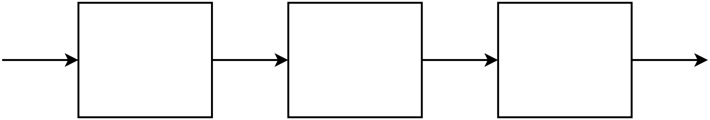

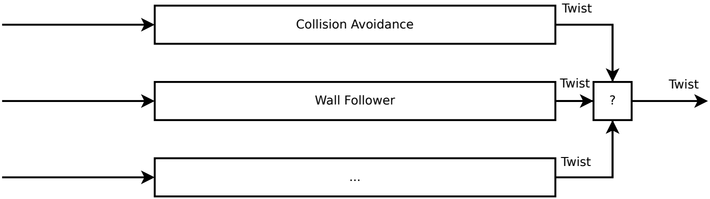

Modular Implementation

This is all nice and all, but pretty abstract.
How to actually implement this modular design?

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  - Examples: std::vector, ros::Subscriber, ros::NodeHandle

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    ... vel = navToGoal(walls, corners, ...);
    ... vel_safe = avoidCollision(vel, laser_data, ...);
    publishVel(vel_safe);
}
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```

- *Whoah, it’s pretty clear what happens!*

Modular Approach Using Functions

- Split up in functions
- Each function implements a re-usable, ’small’ but complete calculation, action, ...
- The function arguments and return types are the interfaces
    - Avoid global variables as much as possible!

```
while(ros::ok()) {
    ros::spinOnce();  // get sensor data
    ... walls = detectWalls(laser_data, ...);
    ... corners = detectCorners(laser_data, ...);
    ... vel = navToGoal(walls, corners, ...);
    ... vel_safe = avoidCollision(vel, laser_data, ...);
    publishVel(vel_safe);
}
```

- *Whoah, it’s pretty clear what happens!*
- Can even split up in separate files

Modular Approach Using Nodes

- One step further: split up in ROS nodes

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    - `rostopic echo ...`
    - Visualization

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- Advantages:
  - Clear separation of data
  - Nodes are processes: run parallel
  - Can inspect communication at run time
    - `rostopic echo ...`
    - Visualization
- Disadvantage:
  - Overhead of using Subscribers and Publishers

Modular Approach Using Nodes

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Directory Structure

```
src/
    wall_detector.cpp
    corner_detector.cpp
    ...
```

Modular Approach Using Nodes

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- Each node has own main function and main loop
- Interface: ROS messages

Directory Structure

```
src/
    wall_detector.cpp
    corner_detector.cpp
    ...
```

CmakeLists.txt

```
rosbuild_add_executable(wall_detector src/wall_detector.cpp)
rosbuild_add_executable(corner_detector src/corner_detector.cpp)
...
```

Recap

Recap

- Using ROS in C++

Recap

- Using ROS in C++
- PICO Safe Drive Example

Recap

- Using ROS in C++
- PICO Safe Drive Example
- Modular Programming

Recap

- Using ROS in C++
- PICO Safe Drive Example
- Modular Programming
    - Determine goal
    - Identify requirements
    - Identify modules
    - Determine interfaces

Recap

- Using ROS in C++
- PICO Safe Drive Example
- Modular Programming
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Recap

- Using ROS in C++
- PICO Safe Drive Example
- Modular Programming
  - Determine goal
  - Identify requirements
  - Identify modules
  - Determine interfaces
- Modular Implementation
  - Using functions
  - Using ROS Nodes

Reminders

- Corridor Competition: Next week!
  - Location: GEM-N, Soccer Field
  - Time: 13.45

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- Wiki page:
  - Document every decision
  - Software design
  - Planning
  - In general: explain how you are going to tackle the problem!