Principles of driver wrapping

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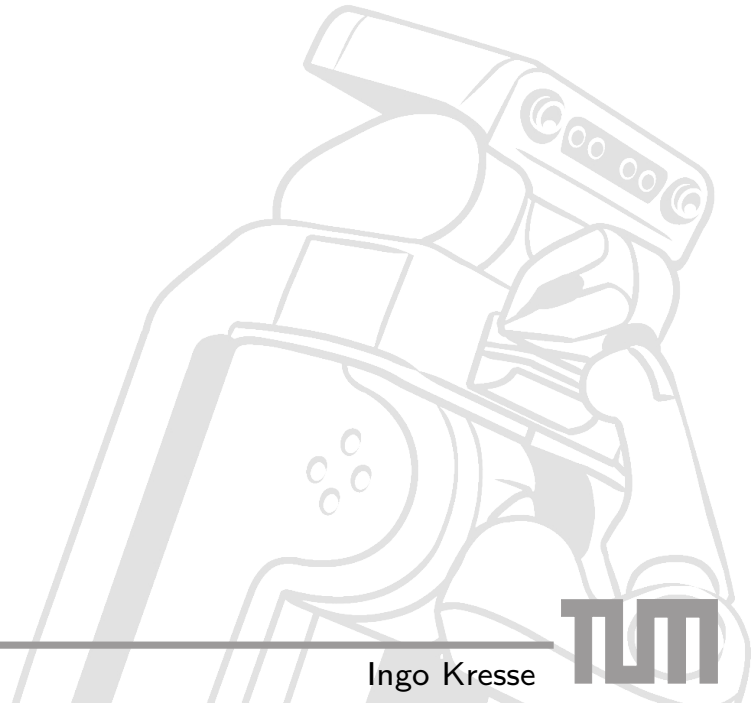
Intelligent
Autonomous
Systems

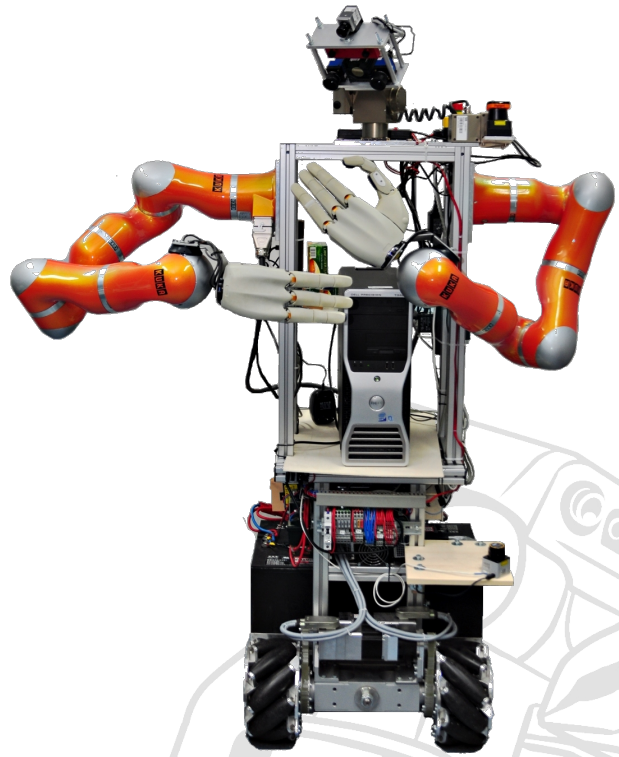
Outline



Motivation

Why hardware drivers in ROS?

- abstract away details of the hardware
- common interface for a type of hardware
- share a piece of hardware between programs
- deal with error conditions

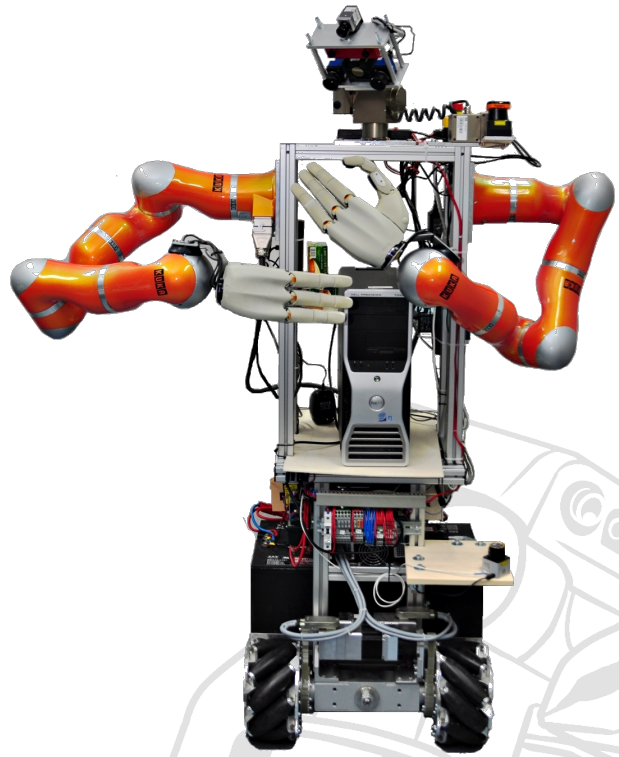


Examples for drivers

ROSIEs hardware:

- 47 motors (arms, hands, wheels, ...)
- 11 sensors (lasers, cameras, kinect, ...)

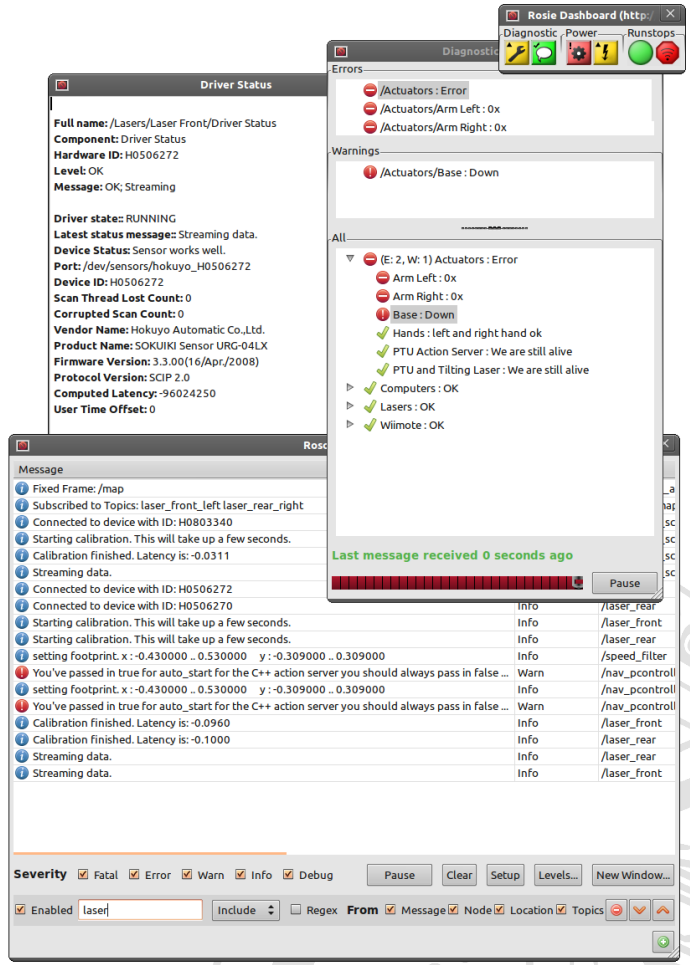
They all can fail independently.



Functionality of a ROS drivers

a good ROS driver should:

- provide standard ROS topics for sensor data / commands
- read its configuration data from roscore (rosparam)
- restart when necessary
- report current hardware state (rosout, diagnostics)



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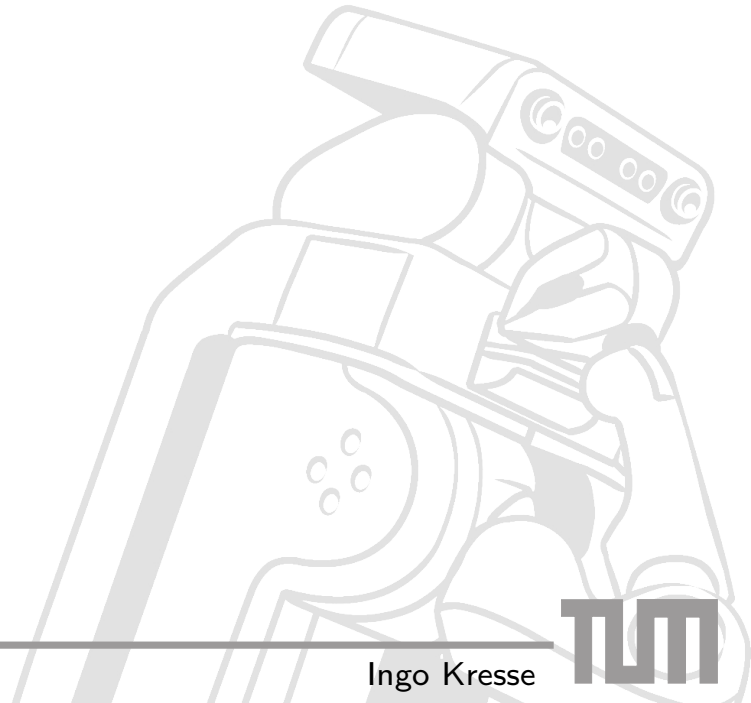
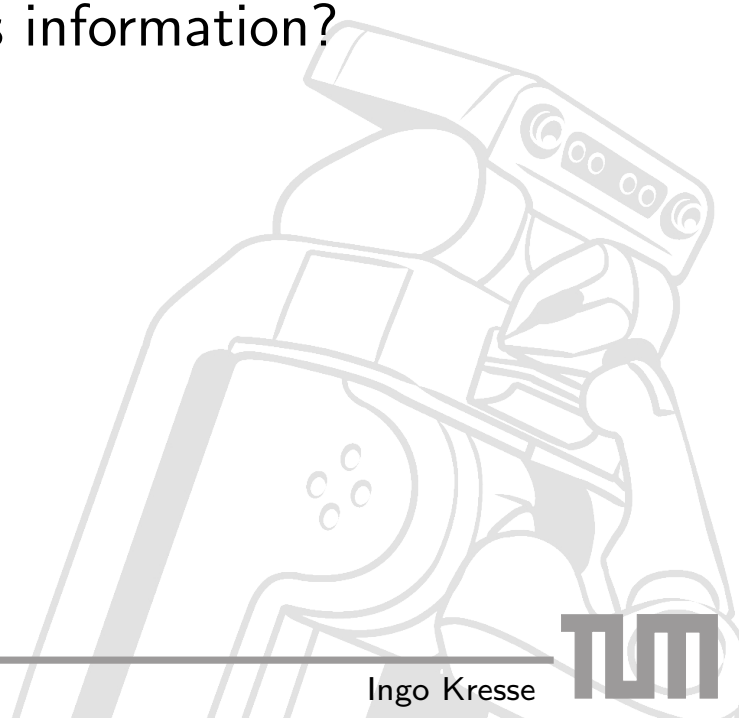


Interface design

Things to consider:

- Hardware capabilities:
  - What commands does the driver understand?
  - What data does the driver publish?
- What messages exist that convey this information? ($\rightarrow$ `rosmsg`)
- How are other drivers doing it?



Example Interface

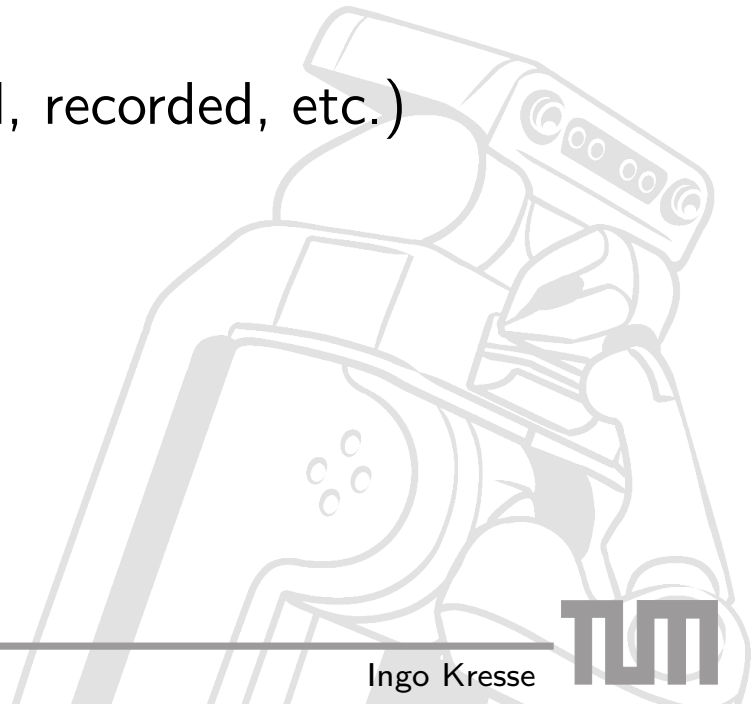
Example: mobile robot base

Interface

- commanded velocity: `geometry_msgs/Twist`
- odometry: `tf`

Advantages of this interface:

- all based on topics (can be monitored, recorded, etc.)
- used by other drivers as well
- simple



Starting to code

Let's use `roscpp`:

manifest.xml:

```
...
<depend package="roscpp"/>
<depend package="geometry_msgs"/>
<depend package="tf"/>
...
```

src/cool_new_base.cpp:

```
#include <ros/ros.h>

...

int main(int argc, char *argv[])
{
    ros::init(argc, argv, "cool_new_base");
    ros::NodeHandle nh("~");
    ...
}
```

Receiving commands

Let's parse the twist command:

src/cool_new_base.cpp:

```
#include <geometry_msgs/Twist.h>

...

void callback(const geometry_msgs::Twist::ConstPtr& msg)
{
    double fwd = msg->linear.x;
    double rot = msg->angular.z;
    ...
}

main(...)
{
    ...
    ros::Subscriber sub = nh.subscribe("/cmd_vel", 1, callback);
    ...
```

Publish odometry

We provide the odometry by publishing a tf transform:

src/cool_new_base.cpp:

```
#include <tf/transform_broadcaster.h>

...

    tf::TransformBroadcaster transforms;

    ...

    tf::Transform pose(tf::Quaternion(tf::Vector3(0, 0, 1), theta),
                       tf::Point(x, y, 0.0));

    transforms.sendTransform(tf::StampedTransform(pose, ros::Time::now(),
                             "/odom", "/base_link"));
    ...
```

Make it run

Give ROS a chance to work:

src/cool_new_base.cpp:

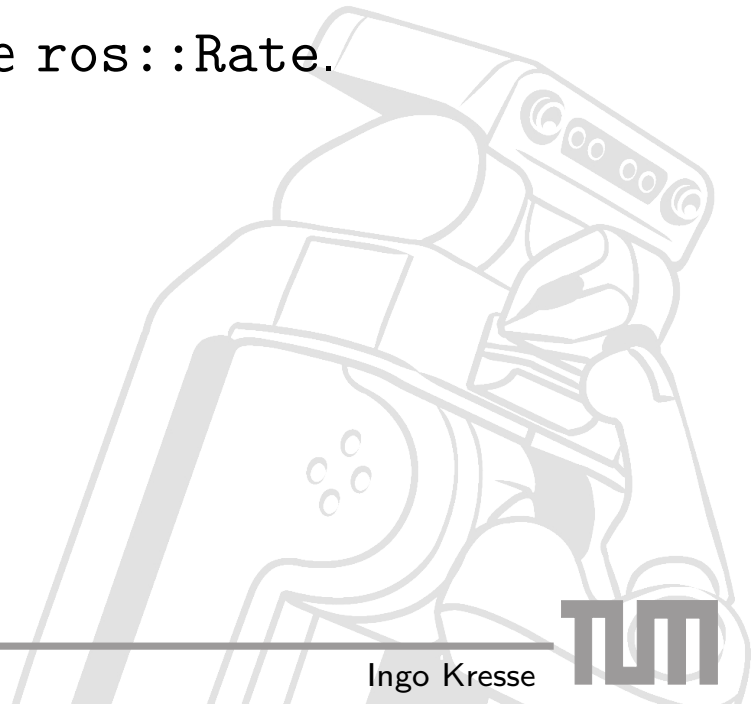
```
...

while(true)  // main loop
{
    ...

    ros::spinOnce();
}

...
```

This makes shure that messages are handled and callbacks are called.

Some remarks on ROS

How to organize the main loop:

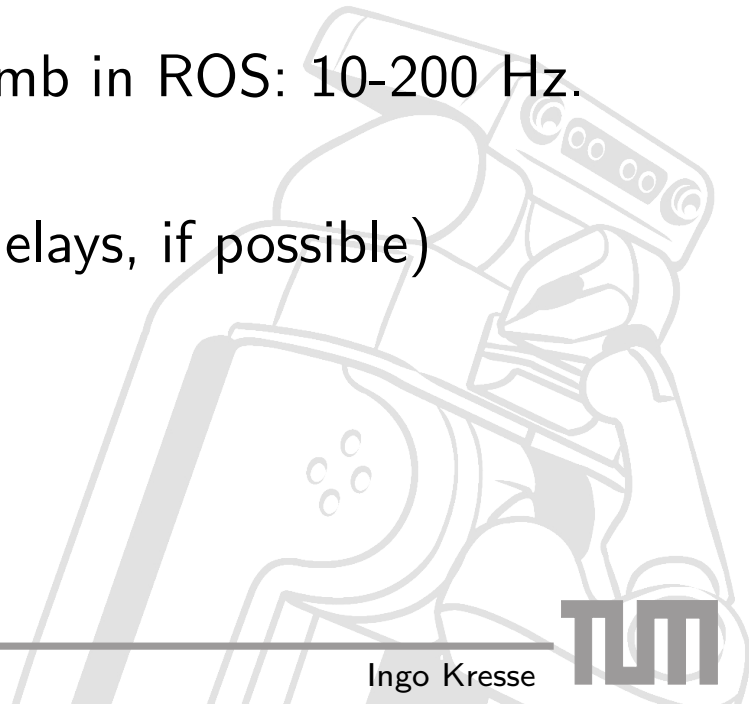
- loop rate required by the device: Usually there is a 'wait-for-new-data' anyway.
  $\rightarrow$ publish every nth data sample.
- (more or less) arbitrary loop rate: Use `ros::Rate`.
- Avoid busy waiting (uses 100% CPU)



Some remarks on ROS

Some more things to consider:

- Callbacks should not block for a long time (everything else will be stalled as well)
- Keep computational load within bounds (also for the consumers)
- Set the data rate 'right': (rule of thumb in ROS: 10-200 Hz. Best option: have a rosparam!)
- Make 'good' time stamps (calibrate delays, if possible)



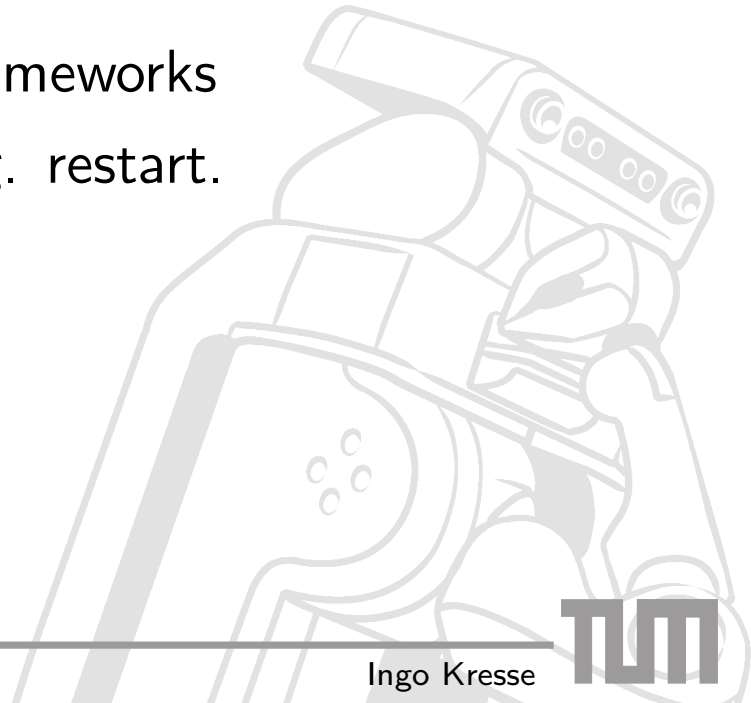
A word on code organization

What about the rest of the code?

- Encapsulate hardware code into separate class (separate file)
- Make separate ROS wrapper class.

Advantages:

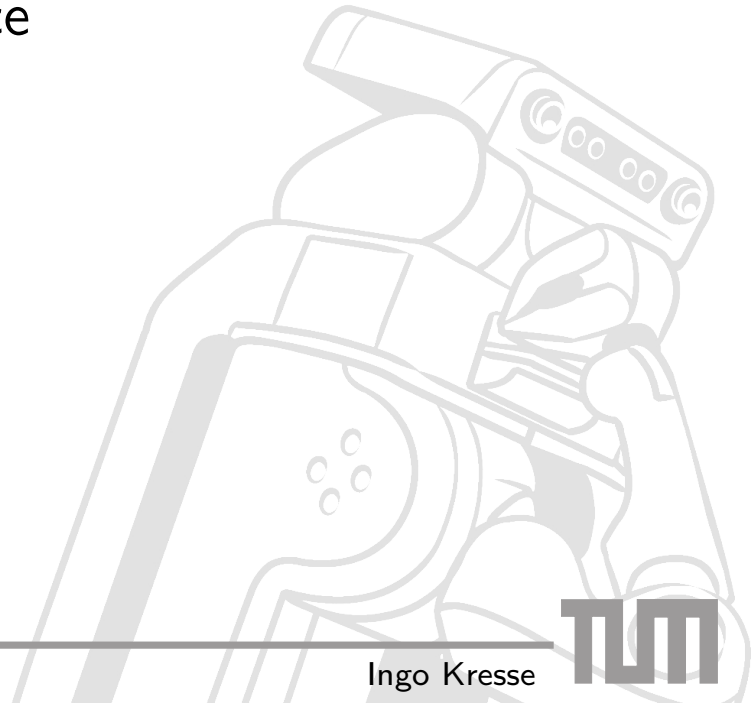
- hardware code is reusable in other frameworks
- ROS wrapper has an easier job to e.g. restart.



Robustness

How can we make a driver robust?

- check whether data is arriving
- check whether data is valid
- when something is wrong: reset device
- keep trying!



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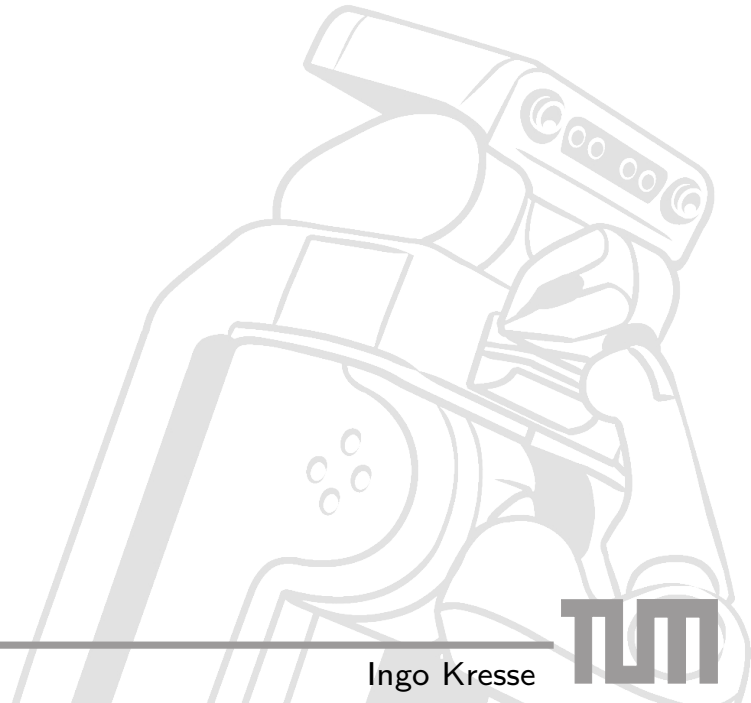


rosparams

ROS Parameters

- do the job of reading parameters from file or command line
- stored in a central place (roscore)
- usually primitive types, but can be structs and lists
- there are tools to change them online

Usage:

src/cool_new_base.cpp:

```
...
double max_speed;
nh.param("max_speed", max_speed, 2.0);
...
```

rosparams

How can we set a ROS Parameter?

- When starting from the command line:

command line:

```
# ./cool_new_base _max_speed:=0.5
```

- Using the `rosparam` tool:

`rosparam` tool:

```
# rosparam set cool_new_base/max_speed 0.5
```

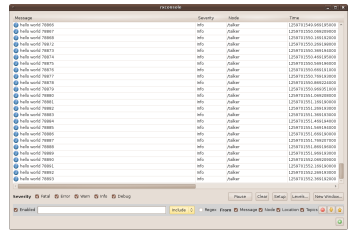
- In a launch file:

cool_new_base.launch

```
...
<param name="max_speed" type="double" value="0.5" />
...
```

ROS Logging system

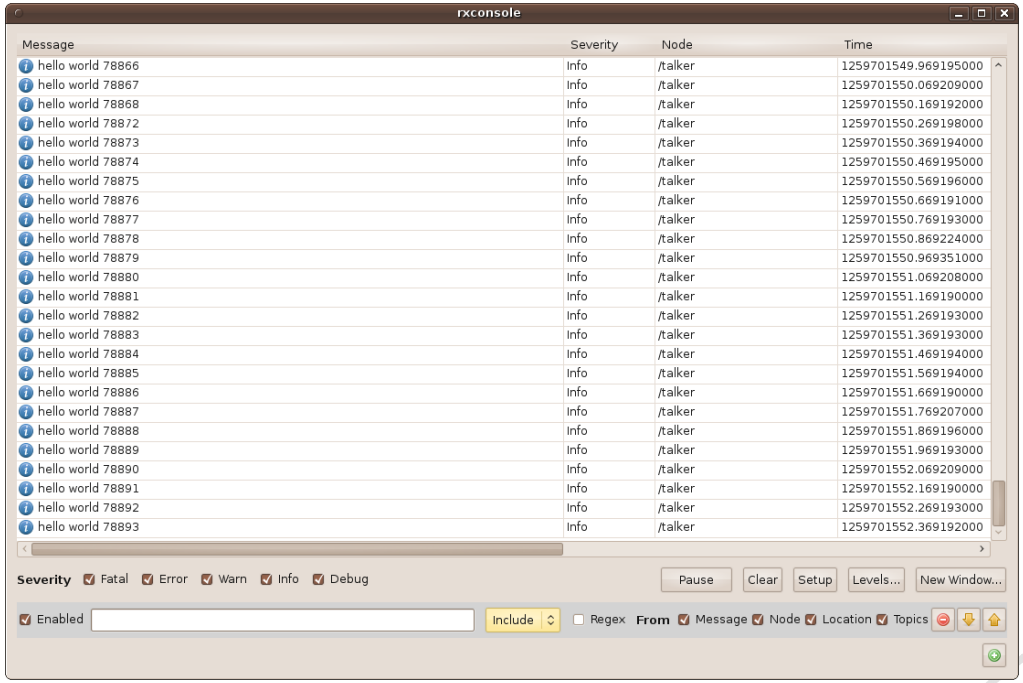
vs.



- has severity levels (DEBUG, INFO, WARN, ERROR)
- reports file name and line number
- travels over the network

ROS Logging system

- powerful console



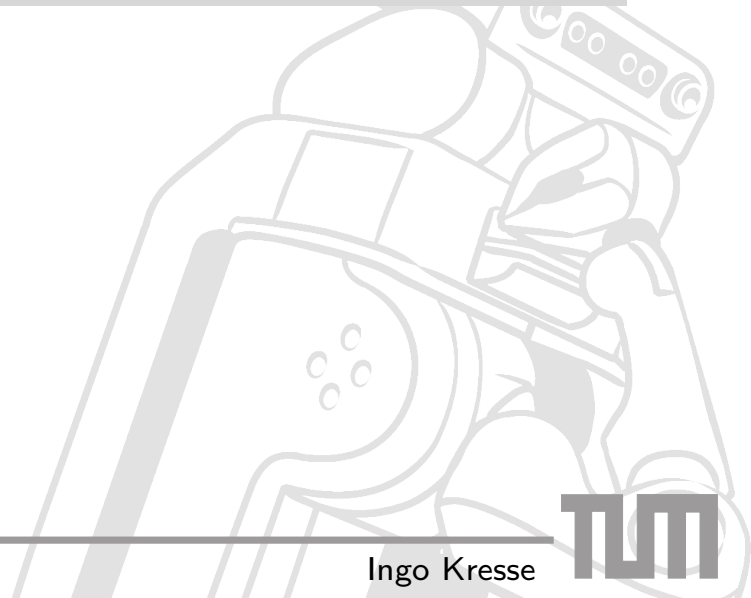
- all message in one place
- extensive filtering capabilities

ROS Logging system

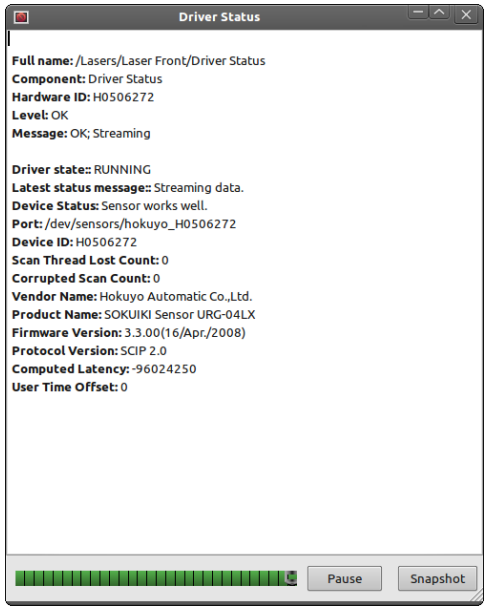
Usage example:

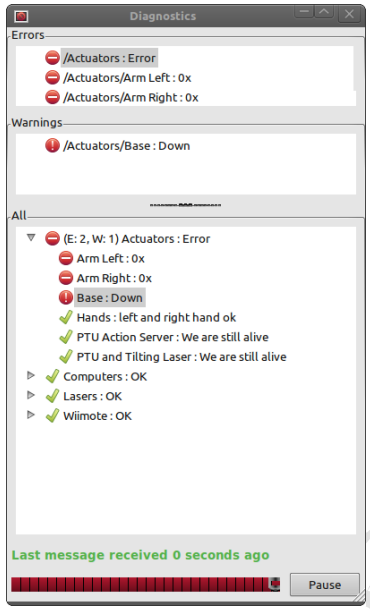
src/cool_new_base.cpp:

```
...
ROS_INFO("initialization took %f seconds", t_elapsed);
...
```



Diagnostics





Purpose:

- keep track of hardware status
- quickly find out “why it’s not working”

Regularly (every 1s) send some status message, containing drivers state.

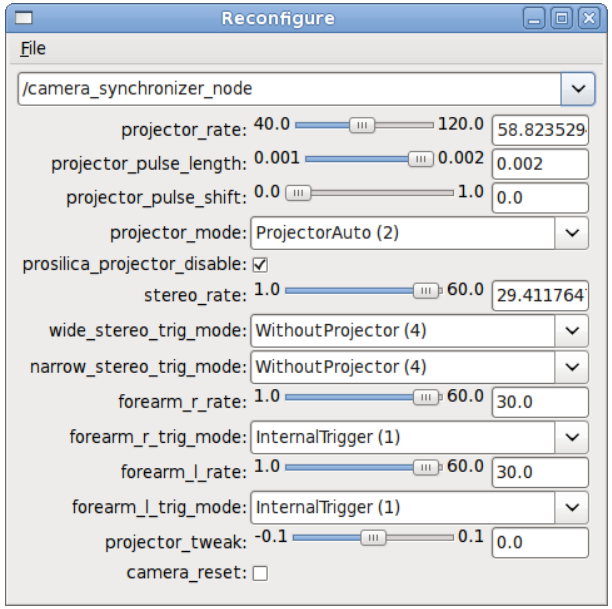
Diagnostics

Code example:

src/cool_new_base.cpp:

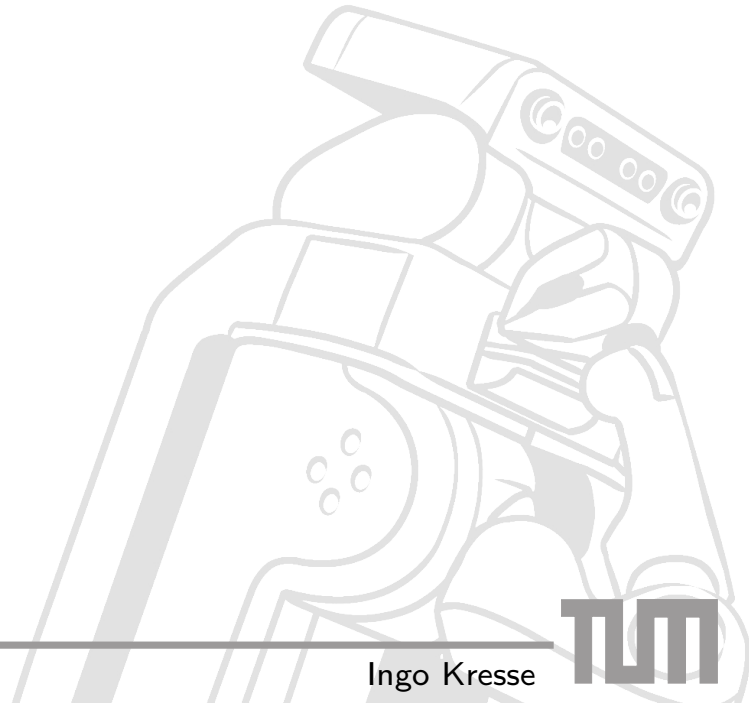
```
void diagsUpdate(diagnostic_updater::DiagnosticStatusWrapper &s)
{
  s.summary(diagnostic_msgs::DiagnosticStatus::OK, "Operational");
  s.addf("important number", "%d", 42);
}
  ...

  diagnostic_updater::Updater diags;
  diags.setHardwareID("cool_new_base");
  diags.add("Base", diagsUpdate);
  ...
  diags.update();
```

Dynamic reconfigure



- Drivers publish details about their parameters (min/max values, etc.) on a topic.
- From this description a GUI is generated.
- The changed configuration is sent using a service call.

Outline



Well, every presentation should have one, right?

- Philosophy is geared towards systems with a lot of hardware
  $\rightarrow$ robustness is a must
- ROS code interface is easy (only a few lines of code)
- There are many ROS tools that help with common tasks (rosparams, rosout, diagnostics, etc.)