Technische Hochschule Rosenheim
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ERTS - Embedded real-time systems

ERTS 11 – ROS2

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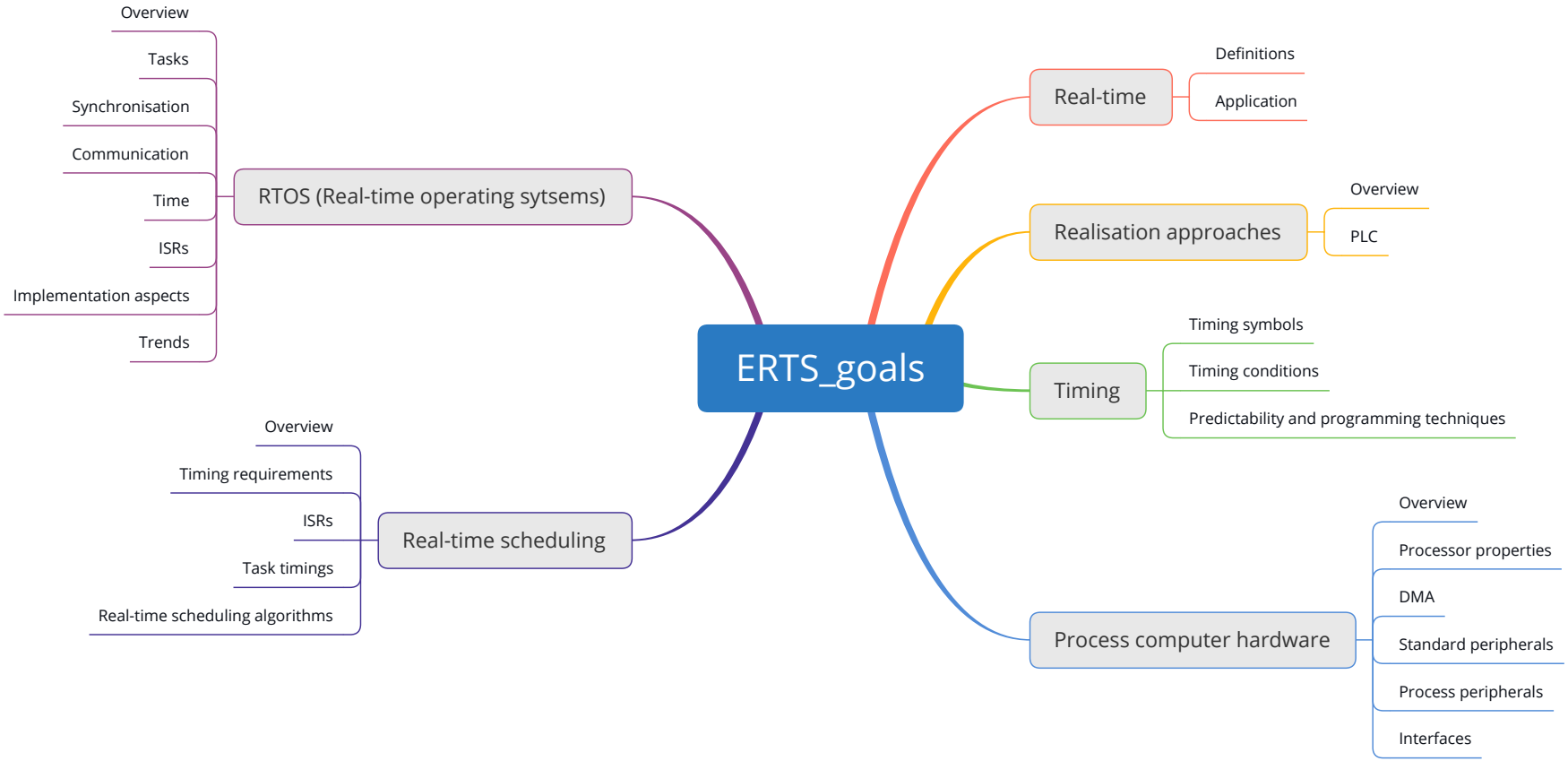
Goal



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Goal

ERTS::ROS2

- ROS2 intro
- ROS2 communication
- ROS2 elements
- ROS2 code sample
- ROS2 workspace and build system
- Turtlebot3

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ROS2 - overview

The **Robot Operating System (ROS)** is a

- set of **software libraries** and **tools**
- for building **robot** applications

History:

- ROS 1 – 2007 (started)
  - Single point of failure (the roscore)
  - Lack of security
  - No real-time support
- ROS 2 – 2015
  - Multi-robot system
  - Multi-platform (Linux, Windows, MAC, RTOS, ...)
  - Real-time support
  - Network connection with QoS (quality of service)
  - Production environments

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ROS2 - releases

Release	Release date	Logo	EOL date
Humble Hawksbill	May 23rd, 2022		May 2027
Galactic Geochelone	May 23rd, 2021		November 2022
Foxy Fitzroy	June 5th, 2020		May 2023

[source: https://docs.ros.org]

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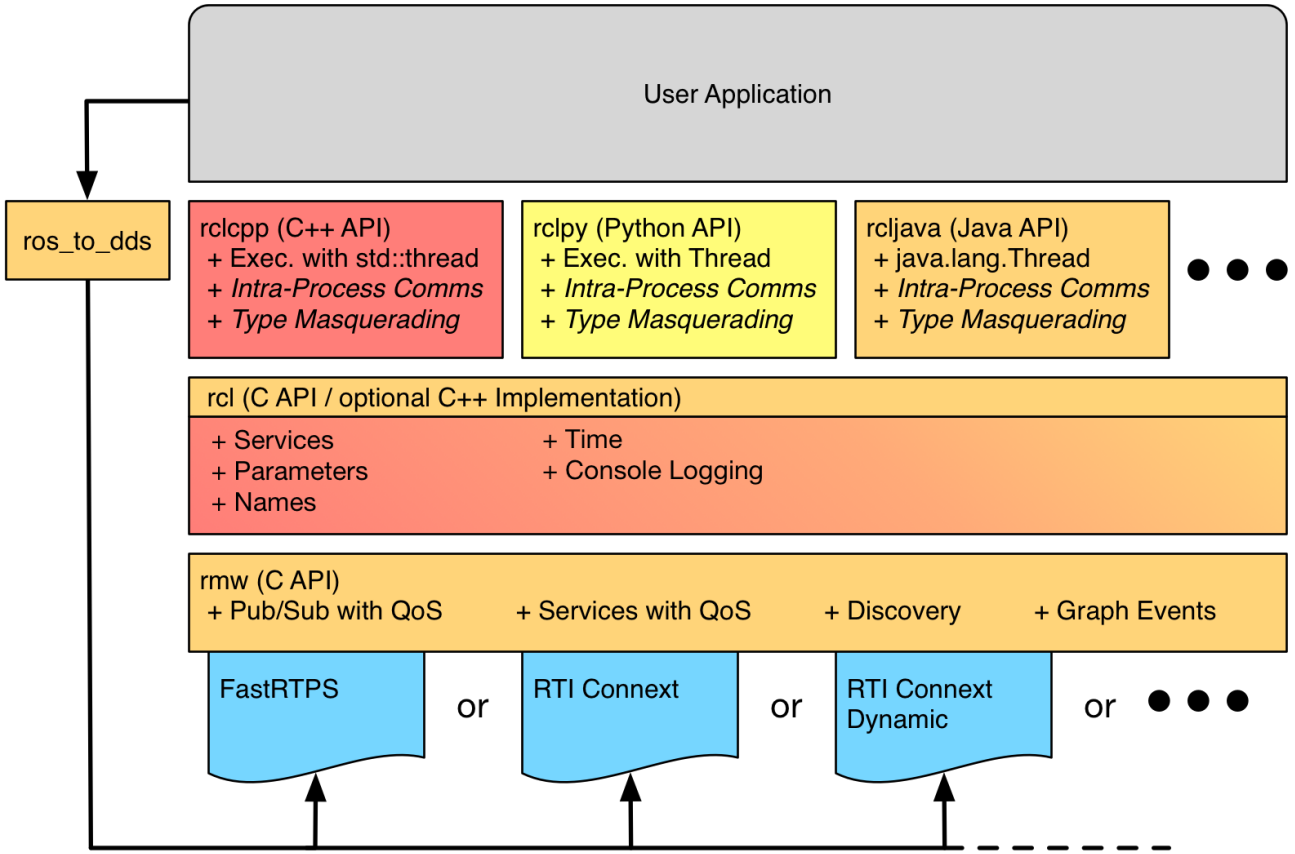
ROS2 - architecture



* *Intra-Process Comms* and *Type Masquerading* could be implemented in the client library, but may not currently exist.

[source: https://docs.ros.org]

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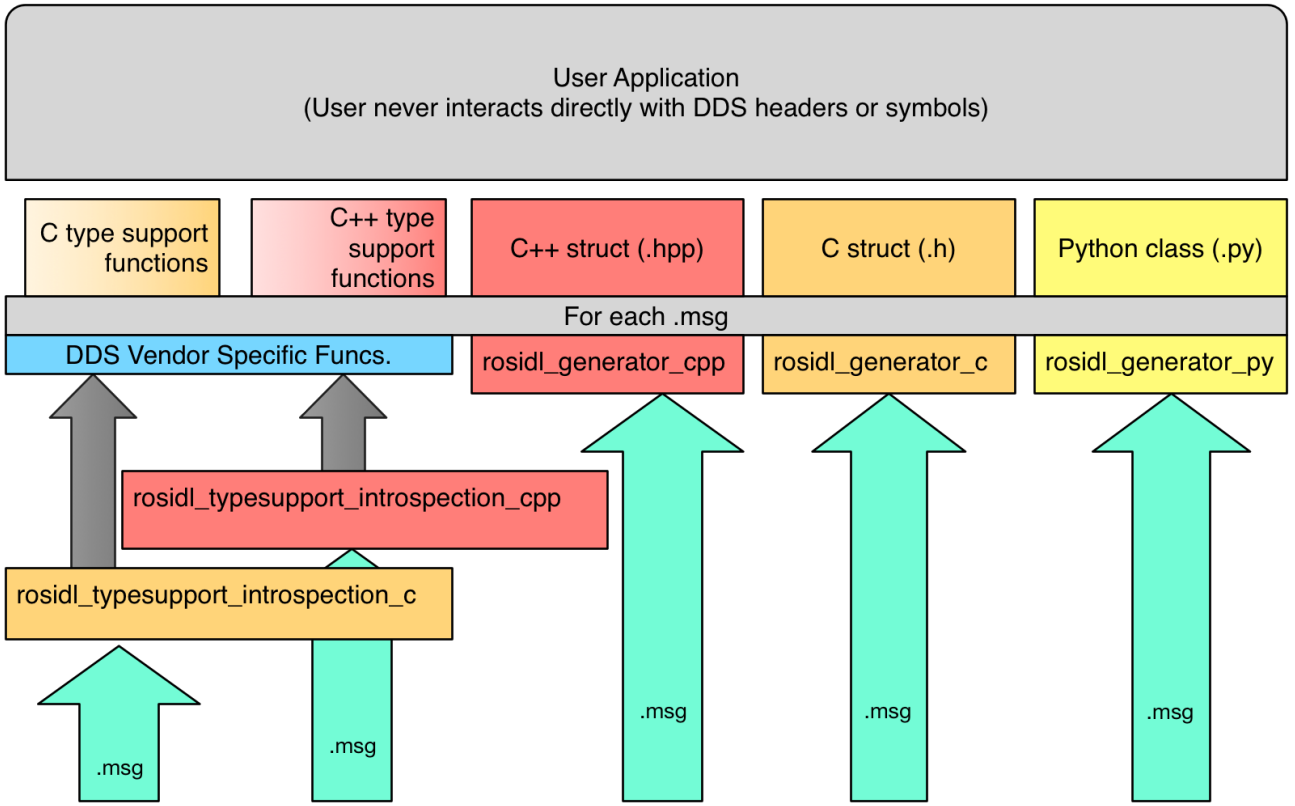
ROS2 - dynamic type support



[source: https://docs.ros.org]

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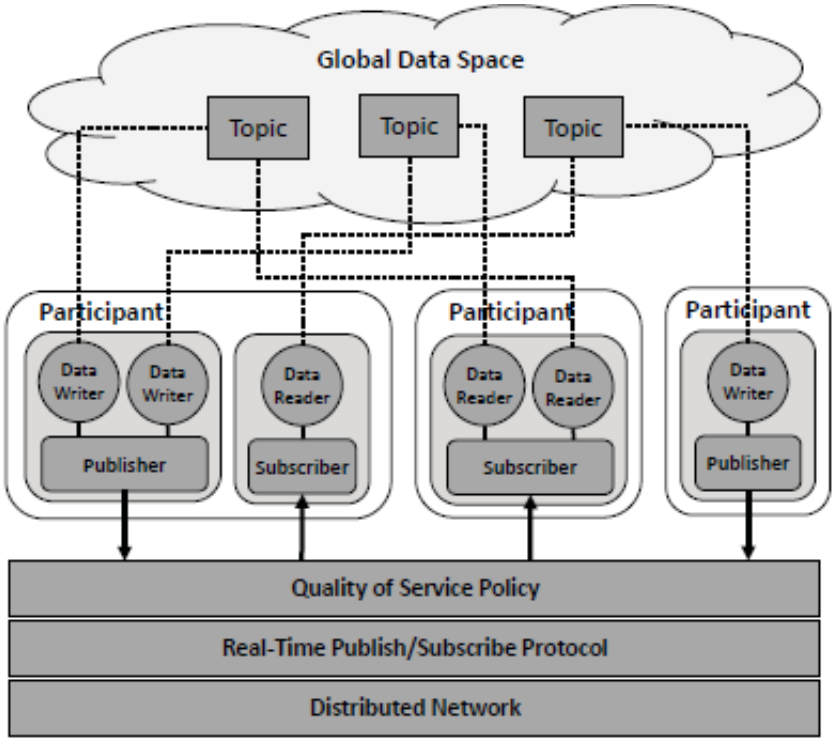
ROS2 DDS communication



[source: etn-sas.eu]

The **Data Distribution Service (DDS)**

- is a **middleware**
- for **machine-to-machine**
- **communication**, using the
- **publish-subscribe** pattern

Properties:

- dependable
- high-performance
- interoperable
- real-time
- scalable data

ROS ID:

- ROS domain id
- Used for discovery and communication
- Automatic discovery mechanism

[source: docs.ros.org]

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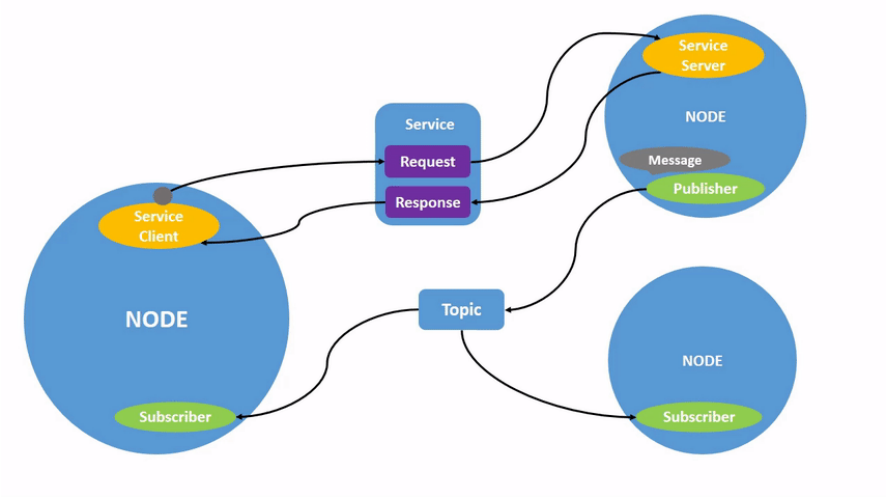
ROS2 elements – node



[source: https://docs.ros.org]

Nodes:

- Send/receive data to/from
  - Topics
  - Services
  - Actions
  - Parameters
- Executable: can contain one or more nodes

Some useful commands:

- `ros2 node list`
- `ros2 node info <node_name>`

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ROS2 elements – node

Example code:

```
1  #include <memory>
2  #include <string>
3
4  #include "rclcpp/rclcpp.hpp"
5
6  class ExampleNode : public rclcpp::Node
7  {
8  public:
9      ExampleNode()
10         : Node("example_node")
11     {
12
13     }
14 };
15
16 int main(int argc, char * argv[])
17 {
18     rclcpp::init(argc, argv);
19     rclcpp::spin(std::make_shared<ExampleNode>());
20     rclcpp::shutdown();
21
22     return 0;
23 }
```

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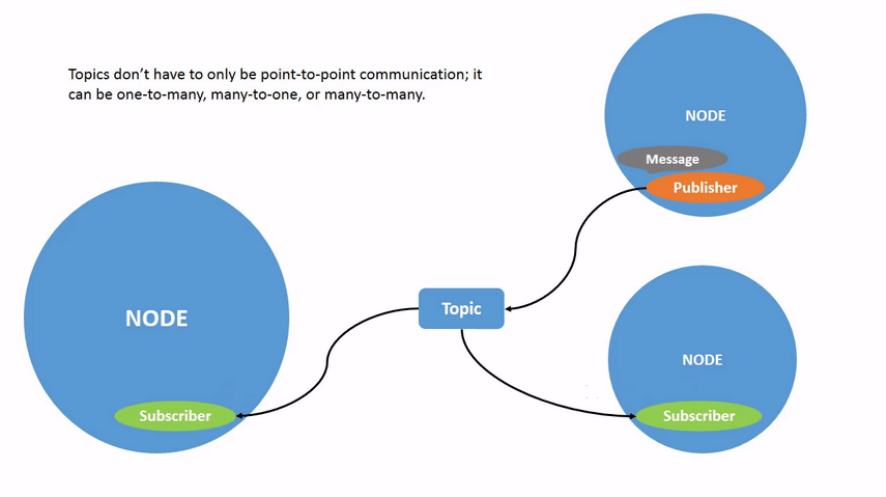
ROS2 elements – topic



[source: https://docs.ros.org]

Topics:

- Act as a bus for nodes to exchange messages
- **Publishers send** messages
- **Subscribers receive** messages
- Multiple publishers possible
- Multiple subscribers possible

Some useful commands:

- `ros2 topic list`
- `ros2 topic list -t`
- `ros2 topic echo <topic_name> #live`
- `ros2 topic info <topic_name>`

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ROS2 elements – message

Example: `geometry_msgs/msg/Twist.msg`

```
# This expresses velocity in free space
# broken into its linear and angular parts.
Vector3  linear
Vector3  angular
```

Basic field types:

Type name	C++	Python	DDS type
bool	**bool**	builtins.bool	boolean
byte	**uint8_t**	builtins.bytes*	octet
char	**char**	builtins.str*	char
float32	**float**	builtins.float*	float
float64	**double**	builtins.float*	double
int8	**int8_t**	builtins.int*	octet
uint8	**uint8_t**	builtins.int*	octet
int16	**int16_t**	builtins.int*	short
uint16	**uint16_t**	builtins.int*	unsigned short
int32	**int32_t**	builtins.int*	long
uint32	**uint32_t**	builtins.int*	unsigned long
int64	**int64_t**	builtins.int*	long long
uint64	**uint64_t**	builtins.int*	unsigned long long
string	std::string	builtins.str	string
wstring	std::u16string	builtins.str	wstring

[source: https://docs.ros.org]

Message:

- Contains one or more members
- Language independent definition
- File: `message.msg`
- Compiled into the target language: C++, python, java

Some useful commands:

- `ros2 interface show <message>`
- `ros2 interface list`

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ROS2 elements – parameters

Example code:

```
1  #include <memory>
2  #include <string>
3
4  #include "rclcpp/rclcpp.hpp"
5
6  class ExampleNode : public rclcpp::Node
7  {
8  public:
9      ExampleNode()
0          : Node("example_node")
1      {
2          this->declare_parameter("velocity", 0.9);
3      }
4
5      void some_function()
6      {
7          double velocity = this->get_parameter("velocity").as_double();
8          //work with velocity
9      }
0  };
```

Parameters can be set:

- from a launch file during startup
- from command line on startup
  `ros2 run ... --ros-args --params-file <path_to_yaml>`
- during runtime through `ros2 param...`

Some useful commands:

- `ros2 param set /<node> <param> <value>`
- `ros2 param get /<node> <param>`
- `ros2 param list <node>`
- `ros2 param dump /<node> --print`

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ROS2 code sample

Code sample for publisher and subscriber

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Example: subscriber

```cpp
#include <memory>

#include "rclcpp/rclcpp.hpp"
#include "std_msgs/msg/string.hpp"
using std::placeholders::_1;

class MinimalSubscriber : public rclcpp::Node
{
public:
    MinimalSubscriber()
        : Node("minimal_subscriber")
    {
        subscription_ = this->create_subscription<std_msgs::msg::String>(
            "topic", 10, std::bind(&MinimalSubscriber::topic_callback, this, _1));
    }

private:
    void topic_callback(const std_msgs::msg::String::SharedPtr msg) const
    {
        RCLCPP_INFO(this->get_logger(), "I heard: '%s'", msg->data.c_str());
    }

private:
    rclcpp::Subscription<std_msgs::msg::String>::SharedPtr subscription_;
};
```

[source: https://docs.ros.org]

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Example: publisher

```
1  using namespace std::chrono_literals;
2
3  class MinimalPublisher : public rclcpp::Node
4  {
5  public:
6      MinimalPublisher()
7          : Node("minimal_publisher"), count_(0)
8      {
9      publisher_ = this->create_publisher<std_msgs::msg::String>("topic", 10);
10     timer_ = this->create_wall_timer(500ms, std::bind(&MinimalPublisher::timer_callback, this
11     }
12
13 private:
14     void timer_callback()
15     {
16         auto message = std_msgs::msg::String();
17         message.data = "Hello, world! " + std::to_string(count_++);
18         RCLCPP_INFO(this->get_logger(), "Publishing: '%s'", message.data.c_str());
19         publisher_->publish(message);
20     }
21 private:
22     rclcpp::TimerBase::SharedPtr timer_;
23     rclcpp::Publisher<std_msgs::msg::String>::SharedPtr publisher_;
24     size_t count_;
25 };
```

[source: https://docs.ros.org]

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ROS2 workspace

```
1 workspace_dir/
2               /build
3               /install
4               /log
5               /src
6                   /package1
7                   /package2
8                   /...
```

Workspace:

- Contains all files
- `/build`: temporary files for build
- `/install`: installed binaries, libraries, resources
- `/log`: log files
- `/src`: source packages

Common commands

- Build all: `colcon build --symlink-install`
- Run all tests: `colcon test`

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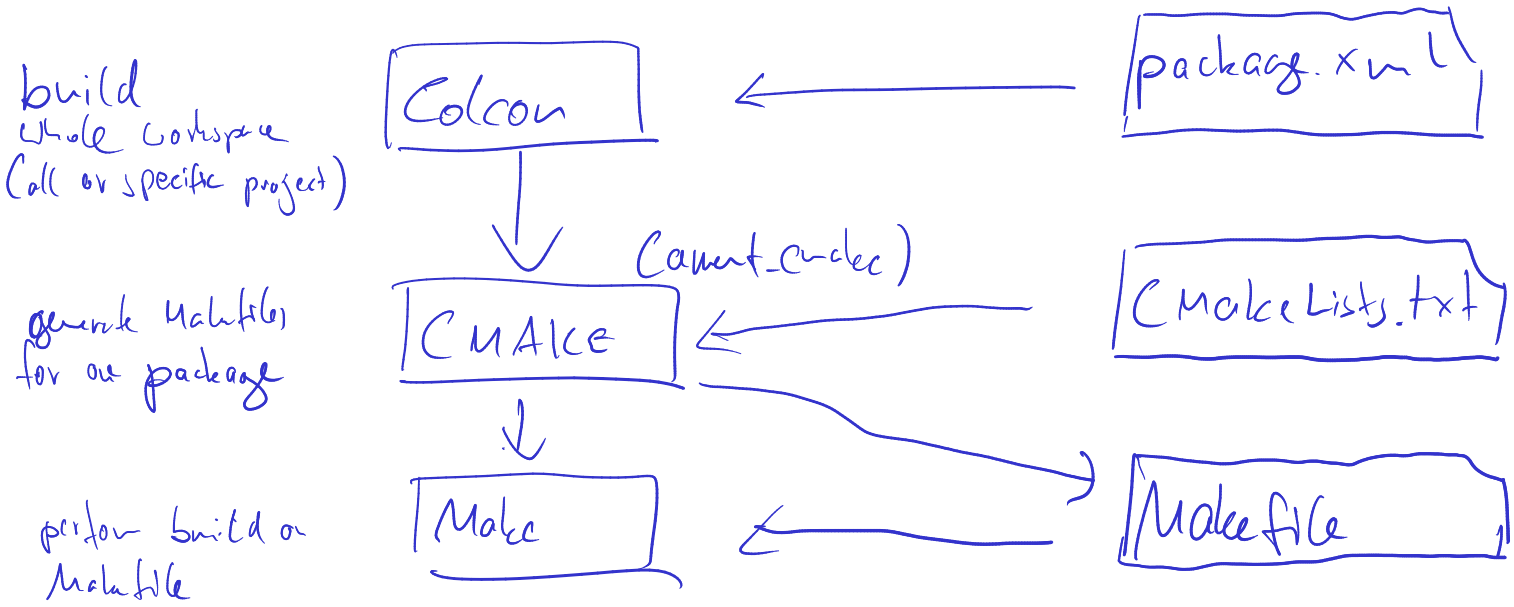
ROS2 build system



[source: https://docs.ros.org]

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ROS2 C++ package

Package in: `workspace_dir/src/`

```
1  my_package/
2            /package.xml
3            /CMakeLists.txt
4
5            /include/
6                /class1.hpp
7            /src/
8                /class1.cpp
9                /node_main.cpp
10           /msg/
11               /CustomMsg.msg
12           /action/
13               /CustomAction.action
14           /srv/
15               /CustomSrv.srv
16           /param/
17           /launch/
18           /map/
19           /rviz/
```

[source: https://docs.ros.org]

C++ cmake based package

- `/include`: Headers and sources
- `/src`: Headers and sources
- `/msg`: Messages
- `/action`: Actions
- `/srv`: Services
- `/param`: Parameters
- `/launch`: Launch scripts
- `/map`: Maps
- `/rviz`: 3D visualization

Common commands

- Create package: `ros2 pkg create --build-type ament_cmake <pkg_name> --dependencies ...`
- Build package: `colcon build --packages-select my_package --symlink-install`
- Run executable: `ros2 run my_package my_package_executable1`

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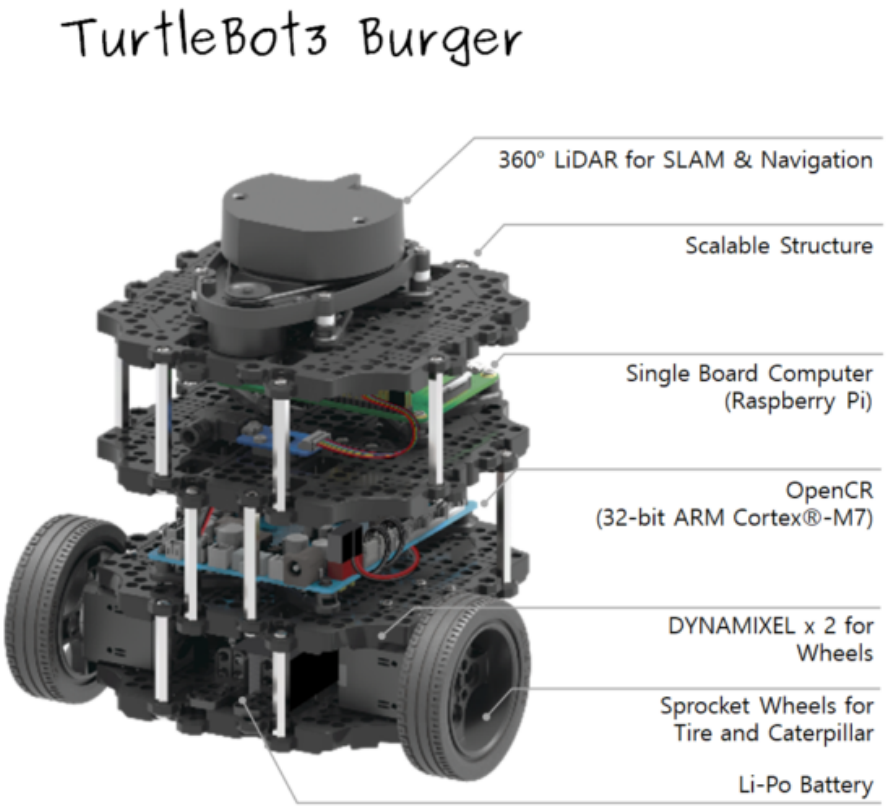
Turtlebot3 - overview



Components:

- Boards:
  - Raspberry Pi 3b plus
  - HW Driver: OpenCR 1.0
- Sensors:
  - Lidar: LDS-01 (HLS-LFCD2)
  - Line follower Array
- Motors: DYNAMIXEL (XL430-W250-T)

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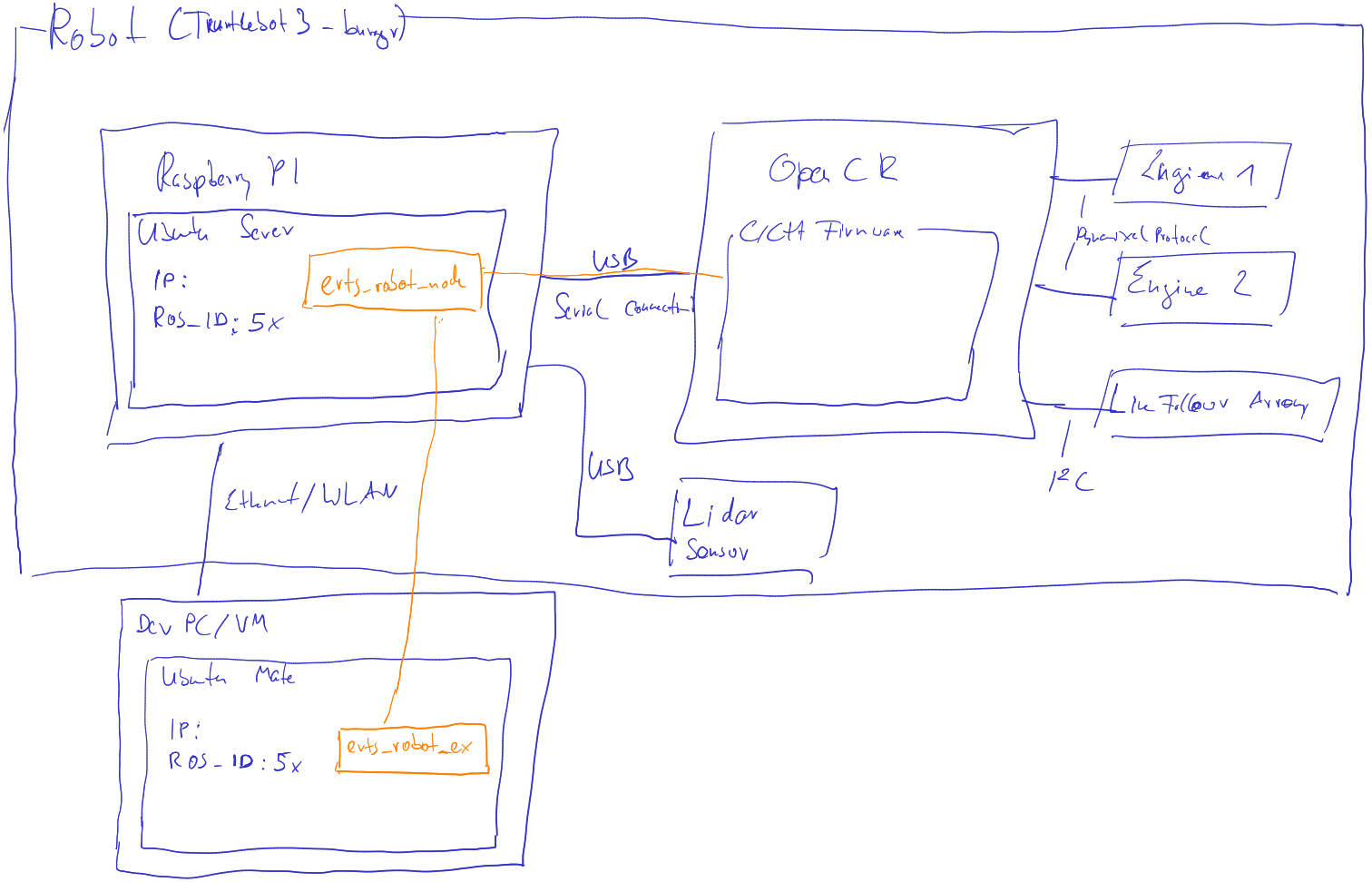
Turtlebot3 - details



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Summary and outlook

Summary

- ROS2 intro
- ROS2 communication
- ROS2 elements
- ROS2 code sample
- ROS2 workspace and build system
- Turtlebot3