

```
interval (std::chrono::milliseconds (10))  
| map ([&](int i)  
    { return mk_msg(hello + std::to_string(i)); })  
| tap ([](const std_msgs::String& msg)  
    { ROS_INFO_STREAM (msg.data); })  
| publish_to_topic<std_msgs::String>  
    ("/chatter", 1000);
```

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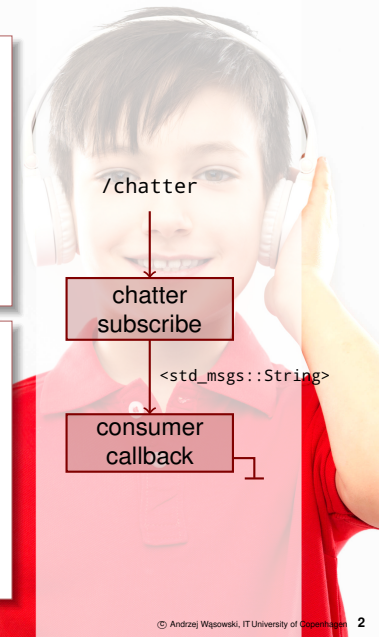
[Reactive] Programming with [Rx]ROS

The Listener Example

```
void chatterCallback(const std_msgs::String::ConstPtr& msg)
{ ROS_INFO("I heard: [%s]", msg->data.c_str()); }

int main(int argc, char **argv) {
    ros::init(argc, argv, "listener");
    ros::NodeHandle n;
    ros::Subscriber sub = n.subscribe("chatter", 1000, chatterCallback);
    ros::spin();
    return 0;
}
```

```
int main(int argc, char **argv) {
    rxros::init(argc, argv, "listener");
    rxros::observable::from_topic<std_msgs::String>("/chatter", 1000)
        .subscribe ( [] (const std_msgs::String& msg)
        {
            ROS_INFO_STREAM ("I heard: [" << msg.data << "]");
        });
    rxros::spin();
    return 0;
}
```



The Listener Example

Key points

■ Problem

- We have a simple mental model in ROS: a **flow graph of messages**
- **We think about callbacks** when we realize it
- Among the most complex control-flow constructs


■ Solution

- Reactive programming gives **simple control-flow**
- **Flow** of information is **explicit in the code**



The Talker Example

```
int main(int argc, char **argv)
{
    ros::init(argc, argv, "talker");
    ros::NodeHandle n;
    ros::Publisher chatter_pub =
        n.advertise<std_msgs::String>("chatter",10);
    ros::Rate loop_rate(10);
    int count = 0;
    while (ros::ok())
    {
        std_msgs::String msg;
        std::stringstream ss;
        ss << "hello world " << count;
        msg.data = ss.str();
        ROS_INFO("%s", msg.data.c_str());
        chatter_pub.publish(msg);
        ros::spinOnce();
        loop_rate.sleep();
        ++count;
    }
    return 0;
}
```



```
int main(int argc, char **argv)
{
    rxros::init(argc, argv, "talker");
    const std::string hello = "hello world ";

    rxcpp::observable<>::
        interval (std::chrono::milliseconds (10))
        | map ([&](int i)
            { return mk_msg(hello + std::to_string(i)); })
        | tap ([](const std_msgs::String& msg)
            { ROS_INFO_STREAM (msg.data); })
        | publish_to_topic<std_msgs::String>
            ("/chatter", 1000);

    rxros::spin();
    return 0;
}
```

The Talker Example

Key points

■ Problem

- We have a simple mental model in ROS: a **flow graph of messages**
- We think about **loops, intervals, counters incremented** when we realize it

■ Solution

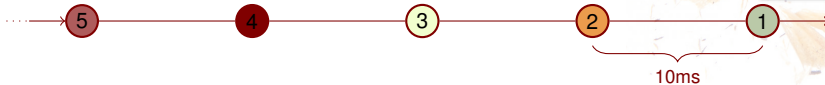
- Functional programming **raises the abstraction level**
- We think about a **incremented stream with a frequency**
- And we **transform** this stream (or messages in it)
- In RxRos publisher and subscriber look **similar**: both are **pipelines**
- In classic ROS they are **very different**: callback vs a loop
- RxROS **parallelizes** pipeline processing
- When you are avoiding callbacks, and remain pure (no side effects) as much as possible, the **need for locks decreases**, and with them concurrency problems



The Talker Example

Marble diagram

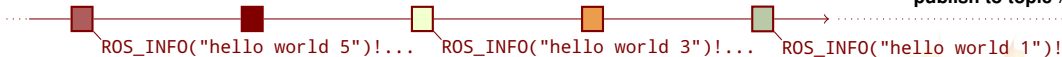
```
interval (std::chrono::milliseconds (10))
```



```
| map ([&](int i) { return mk_msg (hello+std::to_string(i)); })
```



```
| tap ([](const std_msgs::String& msg) { ROS_INFO_STREAM (msg.data); })
```



publish to topic /chatter

The **stream is published** (string messages) to /chatter

```
interval (std::chrono::milliseconds (10))
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RxROS

- RxROS is a **very thin library** (326 lines of C++ header file)
- **Extends RxCPP**, a reactive programming library for C++
- Adds **several ROS-specific operators**: advertiseService, from_topic, from_device, from_yaml, sample_with_frequency, publish_to_topic, call_service
- Available in **melodic** and **kinetic**: apt install ros-melodic-rxros
- Available on **GitHub** <https://github.com/rosin-project/rxros>
- Some **examples** https://github.com/rosin-project/rxros_examples

rosin-project / rxros

Unwatch 2

★ Unstar 8

Fork 3

<> Code

Issues 7

Pull requests 2

Security

Insights

Settings

Reactive programming for ROS

Edit

reactive-programming

rxcpp

ros

Manage topics

82 commits

7 branches

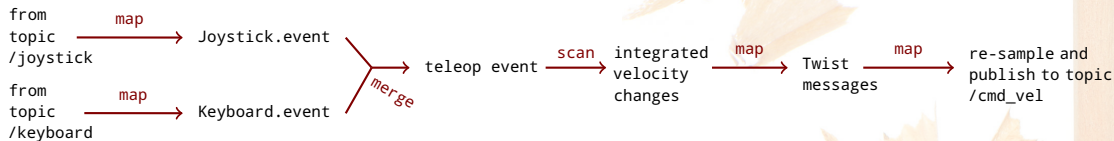
1 release

2 contributors

BSD-3-Clause

VelocityPublisher / TeleOp

```
auto joyObsrv = rxros::observable::from_topic<rxros_teleop_msgs::Joystick>("/joystick") // (
    | map([](rxros_teleop_msgs::Joystick joy) { return joy.event; });
auto keyObsrv = rxros::observable::from_topic<rxros_teleop_msgs::Keyboard>("/keyboard") // (
    | map([](rxros_teleop_msgs::Keyboard key) { return key.event; });
joyObsrv.merge(keyObsrv) // merge the joystick and keyboard messages
| scan(std::make_tuple(0.0, 0.0), teleop2VelTuple) // turn the teleop stream into a linear velocity
| map(velTuple2TwistMsg) // turn the linear and angular velocities into Twist messages
| sample_with_frequency(frequencyInHz) // take latest Twist msg and populate it
| publish_to_topic<geometry_msgs::Twist>("/cmd_vel"); // publish the Twist messages to the topic
```



Challenges Ahead

- **Copying** semantics and **de-allocation** of objects rather complex in C++ (comparing to managed languages)
- Unclear **impact on performance**, more threads (cost) but huge opportunities for parallelization (gain)
- Some **mental cost** in changing the programming paradigm, but there is no going back :)
- Understand **how much of ROS-based code is feasible to write this way**

RoadMap Ahead

- RxROS py
- Action Lib
- RxROS 2, DDS
- RxROS Java? Scala? C#? F#?
- We **seek contributors!**



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