Real-Time Extension to the Robot Operating System

Jan Carstensen
Axel Rauschenberger

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Motivation and Overview

- Introduction
- Architecture
- Communication
  - Publish/Subscribe
  - Services
- Real-Time Debugging
- Example Code
- Current Work
RTROS – Goals and Architecture

Design Goals

- Usability
- Hard Real-Time
- Safety

Architecture

- ROS Node
- RTROS Node
- ROS
- ach
- Ubuntu
- Xenomai
Rate – Cyclic Behaviour

- Cyclic test

- System Latency

Diagram shows the sleep and running states with a scheduled cycle and latency indicated. The graph illustrates the user space latency in microseconds.
Rate Benchmark

- ROS
  - 2.740.15 μs (avg)
  - 21.846.05 μs (max)

- RTROS
  - 0.66 μs (avg)
  - 114.89 μs (max)
Communication

Publish/Subscribe

Services

ServiceServer< ... >

ServiceConnectionRequest

ServiceServer< ... >

ServiceConnectionResponse

ServiceClient<Time>

ServiceRequest<Time>

ServiceResponse<Time>
Publish/Subscribe Benchmark

**ROS**
- 210.24 µs (avg)
- 27.701.19 µs (max)

**RTROS**
- 45.96 µs (avg)
- 179.93 µs (max)

99.843/100.000 (99%) Messages received
100.000/100.000 (100%)
Services Benchmark

ROS

- 26.317,33 μs (avg)
- 47.986,3 μs (max)

RTROS

- 57,35 μs (avg)
- 187,75 μs (max)

100.00/100.000 (100%) Messages received
100.000/100.000 (100%)
Real-Time Debugging

```
[RT-INFO] [1457968417.799695] The default way to output some Information!
[RT-DEBUG] [1457968417.799701] Information vital to debug
[RT-WARN] [1457968417.799703] Something is not going well, maybe this is worth a look!
[RT-ERROR] [1457968417.799704] Something is wrong!
[RT-WARN] [1457968417.799864] Mode switch (reason: invoked syscall). Backtrace:
/home/carstenen/catkin_ws/devel/lib/rtros.so(_ZN5rtros16sigdebug_handlerEiP9siginfo_t
/lib/x86_64-linux-gnu/libc.so.6(+0x36d40)[0x7fde94cfd40]
/lib/x86_64-linux-gnu/libc.so.6(__write+0x2d)[0x7fde958488d]
/opt/ros/indigo/lib/libroscpp.so(_ZN3ros7PollSet6signalEv+0x5a)[0x7fdeae013a]
/opt/ros/indigo/lib/libroscpp.so(_ZN3ros12TopicManager7publishERKSSrKN5boost8functionIFNS_0x234)[0x7fde9ec614]
/home/carstenen/catkin_ws/devel/lib/rtros_test/modeSwitch_talker(_ZNK3ros9Publisher7publishVRK_T+0xb4)[0x40f12e]
/home/carstenen/catkin_ws/devel/lib/rtros_test/modeSwitch_talker(main+0x295)[0x40c5a2]
/lib/x86_64-linux-gnu/libc.so.6(__libc_start_main+0xf5)[0x7fde9baec5]
/home/carstenen/catkin_ws/devel/lib/rtros_test/modeSwitch_talker[0x40c249]
```
Example Code

```c
#include "ros/ros.h"
#include "std_msgs/Time.h"

int main(int argc, char **argv)
{
    ros::init(argc, argv, "ros_talker");
    ros::NodeHandle nh;
    ros::Publisher pub_rts = nh.advertise<std_msgs::Time>("time", 10);

    std_msgs::Time msg;
    ros::Rate loop_rate(1000);
    ros::Time rosTime;

    while (ros::ok())
    {
        rosTime = ros::Time::now();
        msg.data = rosTime;
        pub_rts.publish(msg);
        ros::spinOnce();
        loop_rate.sleep();
    }

    return 0;
}
```

```c
#include "rtros/rtros.h"
#include "std_msgs/Time.h"

int main(int argc, char **argv)
{
    rtros::init(argc, argv, "rtros_talker");
    rtros::NodeHandle nh;
    rtros::Publisher pub_rts = nh.advertise<std_msgs::Time>("time", 10);

    std_msgs::Time msg;
    rtros::Rate loop_rate(1000);
    ros::Time rosTime;

    while (rtros::ok())
    {
        rosTime = rtros::Time::now();
        msg.data = rosTime;
        pub_rts.publish(msg);
        rtros::spinOnce();
        loop_rate.sleep();
    }

    return 0;
}
```
Current Work

- Testing and Improving
- RTROS – Compatibility
  - Preempt_RT
  - Xenomai 3.0
- External Evaluation
  - Open-Source Release
- New Features
  - Network Communication
  - Time Synchronisation
Conclusion

Publish/Subscribe
Services
Time
Transform (TF)
Console

Drivers
Real-Time Restriction
Sensors

TF
/triggerCamera
<sid_srvs::Empty>
/update
<custom_msgs::Update>
/sensor_msgs::LaserScan
/scan
/rtos_node_b
/rtos_node_a
/rtos_node_c
/rtos_node_d

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