Orocos walk-through

Best Practices in integrating complex robotic systems

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Outline

1 Preparation steps

2 Exercise 1 – make a source and a sink

3 Exercise 2 - Add operations to set value, Marshalling

4 Exercise 3 - Basic Ros integration, streaming on topics

Install the software I

Install Ubuntu **16.04**

- Download the ISO
- Create a Bootable USB
- Launch the installer and follow the instructions

Install extra packages

- e.g. `apt-get install git ssh kst`
- install some editor of your liking, qtcreator, kate, kdevelop..

Install the software II

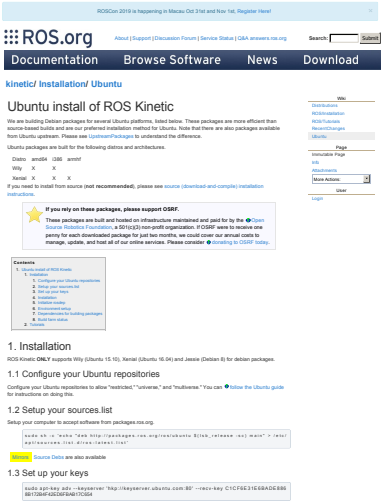
Install ROS Kinetic

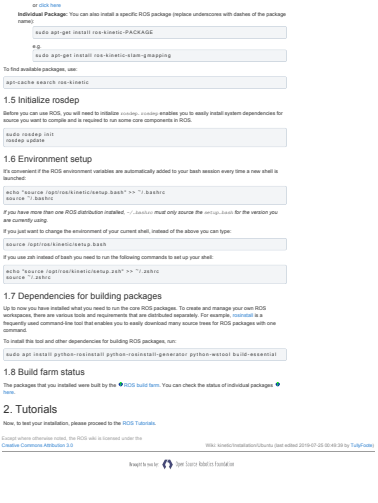
- http://wiki.ros.org/kinetic/Installation/Ubuntu
- choose desktop full meta-package

```
apt-get install ros-kinetic-desktop-full
```

- follows all the instructions of the wiki page up to point 1.7.

Install the software III





Install the software IV

Install Orocos

- `apt-get install ros-kinetic-rtt-ros-integration`

Test Orocos

- run `deployer` in a shell, and see if it works.

Setup a Catkin Workspace

We will use the ros build system, so you will need a catkin workspace to build the exercise:

- `mkdir -p ~/ws/src`
- `cd ~/ws`
- `catkin_make`
- `source devel/setup.bash`

see http://wiki.ros.org/catkin/Tutorials/create_a_workspace.

Automatically generate an orocos package skeleton I

Luckily, there is a command for that:`orocreate-catkin-pkg`

```
Usage: orocreate-catkin-pkg [-f] [--catkin] package_name
[component] [plugin] [service] [typekit] [support] [empty]
[cmake]
```

We consider only the **component** option, *e.g.*:

- `cd ~/ws/src`
- `orocreate-catkin-pkg hello1 component`

Automatically generate an orocos package skeleton II

Generated files

```
- hello1/
        - CMakeLists.txt
        - package.xml
        - src
                - CMakeLists.txt
                - hello1-component.cpp
                - hello1-component.hpp
```

Automatically generate an orocos package skeleton III

Root CMake

```
...
project(hello1)
...
# Rest of the configuration is in src/
add_subdirectory( src )

orocos_generate_package()
```

src CMake

```
...
orocos_component(hello1 hello1-component.hpp hello1-component.cpp)
        # ...you may add multiple source files
...
```

Automatically generate an orocos package skeleton IV

Header

```
#ifndef OROCOS_HELLO1_COMPONENT_HPP
#define OROCOS_HELLO1_COMPONENT_HPP

#include <rtt/RTT.hpp>

class Hello1 : public RTT::TaskContext{
public:
Hello1(std::string const& name);
bool configureHook();
bool startHook();
void updateHook();
void stopHook();
void cleanupHook();
};
#endif
```

Automatically generate an orocos package skeleton V

CPP file

```
#include "hello1-component.hpp"
#include <rtt/Component.hpp>
#include <iostream>

Hello1::Hello1(std::string const& name) : TaskContext(name){
        std::cout << "Hello1 constructed !" <<std::endl;
}
bool Hello1::configureHook(){
        std::cout << "Hello1 configured !" <<std::endl;
return true;
}
bool Hello1::startHook(){
        std::cout << "Hello1 started !" <<std::endl;
return true;
}
void Hello1::updateHook(){
        std::cout << "Hello1 executes updateHook !" <<std::endl;
}
...

ORO_CREATE_COMPONENT(Hello1)
```

Automatically generate an orocos package skeleton VI

Now compile...

Just cd to the root directory, and run `cakin_make` !

...and play with the Deployer

- `import ("hello1")`
- `displayComponentTypes`
- `loadComponent("hello", "Hello1")`
- `cd hello`
- `ls`
- `start`
- `trigger`
- `stop`
- `setPeriod (1)`
- `start`

Inspecting components and commands

All the properties, ports, and operations (included inherited ones) that are documented can be inspected. Try:

- `ls`
- `help name-of-component` *or* `help this`
- `help name-of-component`
- `help name-of-operation/service`

Outline

1. Preparation steps
2. Exercise 1 – make a source and a sink
3. Exercise 2 - Add operations to set value, Marshalling
4. Exercise 3 - Basic Ros integration, streaming on topics

Objectives

- Make a component source that outputs a number
  - Value configurable from property
  - Then a time-dependent function
- Make a component sink that reads the number
  - print out if a new value arrives if periodic and async
- deploy and connect ports

Preparation

- Make a new package `exe1`.
- Prepare the files for two components, `sink` and `source`, and modify `CMakeLists.txt` accordingly.
- Prepare a file called `start.ops`.

Source I

To add Property to the interface

to add a port and write something on it:

```
//hpp; I normally put in private
int output_value;
//cpp, constructor
source::source(std::string const& name) : TaskContext(name,PreOperational)
, output_value(0){
addProperty("output_value",output_value).doc("Value to write out");
}
```

Source II

To add Output Port to the interface

to add a port and write something on it:

```
//hpp
RTT::OutputPort<int> outport_value;

//cpp, constructor
 addPort("outport_value",outport_value).doc("My output value");

//cpp, updatehook
outport_value.write(output_value);
```

Source III

Basic `start.ops`

To import the package and load the two components

```
import ("exe1")
loadComponent("source","source")
loadComponent("sink","sink")
```

Now compile, and check if data is written with “leave” (in Deployer)

```
cd source
configure
start
leave
var int i
outport_value.read (i)
i
enter
```

Sink I

To add Ports to the interface

to add input ports and get data

```
//hpp
RTT::InputPort<int> inport_value;

//cpp, constructor
addPort("inport_value",inport_value)
        .doc("My input port");

//cpp, updatehook
int data_in;
RTT::FlowStatus fs = inport_value.read(data_in);
if (fs==RTT::NoData){std::cout<<"no data"<<std::endl;}
else if(fs==RTT::OldData){std::cout<<"old data"<<std::endl;}
else {std::cout<<"data: "<< data_in<<std::endl;}//fs=RTT::NewData
```

Sink II

Now compile, and check if data can be written with “leave” (in Deployer)

```
cd sink
start
leave
inport_value.write(1)
sink.trigger
```

Sink III

Event Port

they works similarly to normal input ports, but a function will be called every time they receive data. (**default: updateHook**)

```
//hpp
RTT::InputPort<int> event_inport_value;
//cpp, constructor
addEventPort("event_inport_value",event_inport_value)
  .doc("My input port - event");
```

Sink IV

Event Port make it complex

Use a **callback** in place of the default updateHook

```
//cpp, constructor
addEventPort("event_inport_value",event_inport_value,boost::bind(&sink::my_callback, this,_1))
  .doc("My input port - event");
//cpp
void  sink::my_callback(RTT::base::PortInterface*p){
  this->trigger();
  std::cout<<"callback"<<std::endl;
}
```

- to call the update from the callback, use `this->trigger()`
- to put a generic (*e.g.* member class) function, use `boost::bind`

Sink V

Question

why callback is written before the text in the updateHook?

Deployment

```
import ("exe1")
loadComponent("source","source")
loadComponent("sink","sink")
source.setPeriod(1)
source.configure
source.output_value=3
connect("sink.event_inport_value","source.outport_value",ConnPolicy())
sink.start
source.start
```

Make a the source a sine generator

write a signal (*e.g.* sine with period and amplitude configurable from properties) to a port. Hint: a periodic component can retrieve his period with get period: otherwise, you can get time with the following:

```
//hpp
#include <rtt/os/TimeService.hpp>
...
private:
...
RTT::os::TimeService::ticks time_begin;
//cpp, starthook
time_begin=RTT::os::TimeService::Instance()->getTicks();
//cpp, updateHook
double time_passed=RTT::os::TimeService::Instance()->secondsSince(time_begin);
```

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Objectives

- Add an operation `set_amplitude` and `set_frequency` to the `source` component
- protect the amplitude and frequency so that they can be loaded only at configure time.
- Make a configuration file, and load before configure.
- protect the change via operation so that is possible to do it only when the `source` component is stopped.

Preparation

- make another component `source2`, copying `source`.
- make another deployment script, `start2.ops`.

Properties I

- Properties are variables that you can read and write
  - from the component and
  - from the component interface.
- The main use of properties is to configure a component, via the **Marshaller** service, or scripts.

Properties II

```
//hpp
int my_property;
//cpp, constructor
addProperty("my_property",my_property).doc("A property");
//cpp, updateHook
my_property=34;
int var=my_property;
```

Property changes dynamically!

If you do not what to allow to change the variable at anytime, cache it, or consider a setter/getter operation!

Protect Properties

- create other two variables for caching (hint, rename properties as `_prop`)
- copy values in configure hook
- Maybe is a good idea to document in the `.doc` the behaviour!

Make a file for properties

- load the marshalling servicesource.loadService ("marshalling")
- play around a little with it...
- generate a file
- modify the file and read it again

```
Deployer [S]> source.loadService ("marshalling")
= true
Deployer [S]> source.marshalling.writeProperties ("prop.cpf")
= true
//modify file
Deployer [S]> source.marshalling.readProperties ("prop.cpf")
= true
```

A configuration file example

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE properties SYSTEM "cpf.dtd">
<properties>
        <simple name="amplitude" type="double"><description>Value amplitude</description>
                <value>2</value></simple>
        <simple name="frequency" type="double"><description>Value frequency</description>
                <value>0.1</value></simple>
</properties>
```

Exercise: Now make read persistent, before the configure hook (write command in deployment script)

Add Operations I

Add an operation to the interface

```
//hpp - declare class function
        bool set_amplitude(double);
//cpp constructor
        addOperation( "set_amplitude",  &source2::set_amplitude, this, RTT::OwnThread)
          .doc("Set The amplitude");

//cpp, function body
        bool source2::set_amplitude(double a){
          ...
        return true;
        }
```

Add Operations II

Now make sure that the operation cannot modify variables during running

Hint

the tast context offers introspection on his on life cycle state machine:

- `this->isRunning()`
- `this->isConfigured()`
- `this->inException()`
- `...`

Add Operations

Now make sure that the operation cannot modify variables during running

```
bool source2::set_amplitude(double a){
        if (this->isRunning()){
                RTT::Logger::In in(this->getName());
                RTT::log(RTT::Error)<<" set amplitude failed, component is running"<<RTT::endlog();
                return false;
        }
        amplitude_prop=amplitude=a;
        return true;
}
```

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Steps for streaming on a topic

- using for ports the typekit generated from ros messages.
- loading the Ros services.
- use the stream command

see https://github.com/jhu-lcsr/rtt_ros_examples

Integrate a ros messages-generated typekits in a component

Using a Ros message is the same of using any other type.

```
// hpp
        #include <std_msgs/Float64.h>
        ...
        RTT::OutputPort<std_msgs::Float64> outport_value_ros;
//cpp, constructor
        addPort("outport_value_ros",outport_value_ros).doc("My output value, ros");
//cpp, update hook
        std_msgs::Float64 f;
        f.data=val;
        outport_value_ros.write(f);
```

In deployment...

Using a Ros message is the same of using any other type.

```
import("rtt_ros")//optional, allows to import with the dependecies of package.xml
import ("rtt_std_msgs")
import("rtt_rosnode")//makes orocos a ros node. will complain if roscore is not running
import("rtt_roscomm")//contains the topic services
... load, configure, ...
stream("source.outport_value_ros", ros.topic("float_out"))
```

Build a new typekit from a ROS message I

create a Ros package with only msgs

```
catkin_create_pkg my_custom_msgs std_msgs rospy roscpp
```

write a msg in the msg folder

```
Float64 x
Float64 y
```

Modify, following the instructions in `CMakeLists.txt`, the files

- `CMakeLists.txt`
- `Package.xml`

. . . and compile with `catkin_make`.
More info: http://wiki.ros.org/ROS/Tutorials/CreatingMsgAndSrv

Build a new typekit from a ROS message II

Generate the typekit

We will use a facility of the rtt_roscomm package (github.com/orocos/rtt_ros_integration/tree/indigo-devel/rtt_roscomm)

```
rosrun rtt_roscomm create_rtt_msgs my_custom_msgs
```

then compile and try to load the typekit, as for the `rtt_std_msgs`