Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Graphical User Interface for Roboscoop Applications

Bachelor Thesis

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Abstract

Software written for robotics, where the user interacts with the robot, often consists of two major parts: The Graphical User Interface (GUI), which is used to get inputs from the user, while the controller makes calculations and navigates the robot. The two parts are logically separated and don't interact much with each other. Although the controller mainly has to stay on the hardware of the robot, the GUIs are more free and could also be located on a remote device.

The two parts are modular: Two different applications could have identical GUIs and on one application could have multiple very different GUIs. The work needed to provide a stable network communication between the parts is very similar in distinct applications.

This thesis aims to provide a protocol to simplify the work to connect GUIs and Controller in such applications. The focus of this solution is on the simplicity of the usage and to provide enough freedom for the developer in the design choices he is making, such as programming language or number of GUIs.

Contents

Chapter 1

Introduction

1.1 Motivation

The Roboscoop framework [2] is aimed at resolving coordination, synchronization, and other concurrency issues for robotics. It is based on SCOOP (Simple Concurrent Object-Oriented Programming) [1], a programming model for concurrency that excludes data races by construction. However, it lacks the convenient and functional graphical interfaces needed for better interaction with robots.

To simply write GUIs for those applications would not be very far-sighted. A flexible approach, where the work of the Roboscoop developer who writes a GUI can be simplified, would be more beneficial. Furthermore it is likely that the developer of the controller and the GUI are not the same person and a restriction of the programming language to be the same for both parts would be an unnecessary constraint.

Although the protocol is meant for Roboscoop applications, there is no need to make it dependent on Roboscoop. A standalone protocol could be used for other applications in and outside of robotics which follow the same structure, a separation of GUI and the rest of the software.

1.2 Overview of the Thesis

The contents of the different chapters of the thesis are briefly described.

- Requirements

  This section describes what the protocol needs to provide in able to be useful.

- Architecture

  This chapter explains the basic structure of the protocol and how the different parts communicate with each other.

- Evaluation

  The capabilities of the protocol are discussed in this section with help of two examples.

- Limitations and Future Work

  This section lists the limitations of the protocol and what could be done to improve it in the future.

- Results and Conclusion

  This chapter sums up the findings of the thesis and comes to a conclusion.

- Appendix A: Interfaces

  The technical details of the Interfaces for the GUI and controller to communicate with the server are listed here. This section is important when using the protocol.

- Appendix B: Documentation

  This appendix describes the architecture of the protocol in depth.

- Appendix C: Code

  The last appendix contains all code of the thesis. This includes the Protocol, two sample GUIs and two sample controllers.

Chapter 2

Requirements

For the protocol to be useful, the cost for the developer to get to know and implement it must be as low as possible. This has to be achieved while keeping restrictions to the functionality at a minimum.

It is certainly possible to use the protocol for a controller and a GUI on the same hardware, but to tap its full potential the two components are separated by a network. The protocol has to be robust and account for unwanted behavior on this channel, like duplication or loss of data.

Although the protocol can be used on its own, the main focus lies on writing GUIs for Roboscoop applications. As Eiffel is the language of Roboscoop, it has to be possible to work with the protocol in Eiffel and with SCOOP.

Generally the communication between the GUI and controller is very asynchronous. In this protocol the communication in direction GUI to controller is called *COMMAND*. Such a *COMMAND* has a name and attributes and is almost exclusively used to forward user input. Messages in the other direction are called *STATUS*. A *STATUS* can be a state of the robot, such as a position or speed, or a state of the server, for example a parse error. The protocol has to work optimally for this asynchrony.

To summarize the requirements:

- Low overhead
- Few restrictions
- Robustness
- SCOOP/Eiffel
- *COMMAND/STATUS*

Chapter 3

Architecture

3.1 Language and Framework

The possibility to extend the Roboscoop framework was discarded because having a Roboscoop application is not necessary to run the framework. Instead it is implemented as an Eiffel-Library. With this design choice the protocol works as a standalone and can be used to develop applications for robotics from scratch. Both mentioned possibilities restrict the programming language of the controller to Eiffel. Lifting this restriction and still being able to work with Roboscoop applications would increase the complexity of the protocol too much.

Since it's a main goal of the protocol to separate the GUI physically from the controller, the restriction of using Eiffel as programming language for the GUIs can be lifted with only a slight increase of complexity. With the use of sockets and a JSON subset a GUI written in any programming language can communicate with the protocol. This separation makes the simultaneous support of multiple GUIs easier.

3.2 Basic Structure

Figure 1 shows a complete class diagram of the protocol. The protocol works in a server-client structure where the server is a part of the protocol whilst the clients are the GUIs. It consists of three main parts; the controller-interface, the buffer and the server. The server uses the buffer to communicate with the controller-interface/controller and uses sockets to communicate with the GUIs.

In an attempt to simplify the connection between GUI and server/controller the server listens to a broadcast on a predefined port. It replies with a broadcast containing the IP-address and port of the socket to connect to.

Those values are defined at creation of the server. With this method, the GUI can be programmed to work in a changing network environment.

Because of the controller, buffer and server running on the same application, concurrent computing is an important topic. The protocol uses **separate** objects from SCOOP as an alternative to EiffelThreads because Roboscoop also works with these objects. This means that Roboscoop applications are already configured to use **separate** objects and there is no additional configuration work to do. The keyword **separate** is used to describe an object which can be accessed from different processors. The SCOOP framework handles concurrency of such objects and excludes data races. This additional layer of abstraction makes the framework easy to develop with.

The controller, which the user of the protocol has to write, can be written without using Scoop because of the controller-interface handling the concurrent computing. This can be more useful when the protocol is used as a standalone without Roboscoop.

Another part of the library is the console listener which listens to the "stop" string in the console and halts the execution if it detects it.

3.3 Communication

There are three important types of communication between protocol and GUI. Figure 2 shows a simplified runtime-diagram of them.

- The *COMMAND* is the GUI's tool to communicate with the server and controller. Mostly, it is used to forward user input from the GUI through the server to the controller in order to control the robot, but it is also used to send instructions directly to the server. To request all possible *COMMANDs* and to register for a *STATUS* are the most important instructions.
- The *STATUS* is sent from the controller to the server while a GUI can register to it. They represent states of the robot which are of interest to the GUI. If a GUI has registered to such a *STATUS*, it is notified every time when it changes. Different GUIs can register to different (overlapping) sets of *STATUSes*.
- The Command Instruction is sent from the controller to the server and determines the commands and arguments which the server forwards from the GUI to the controller. If a command does not comply with the guidelines, the server sends an error message back to the GUI and does not forward a message to the controller. The main goal of this tool is to simplify the writing of a GUI to a controller written by another developer.

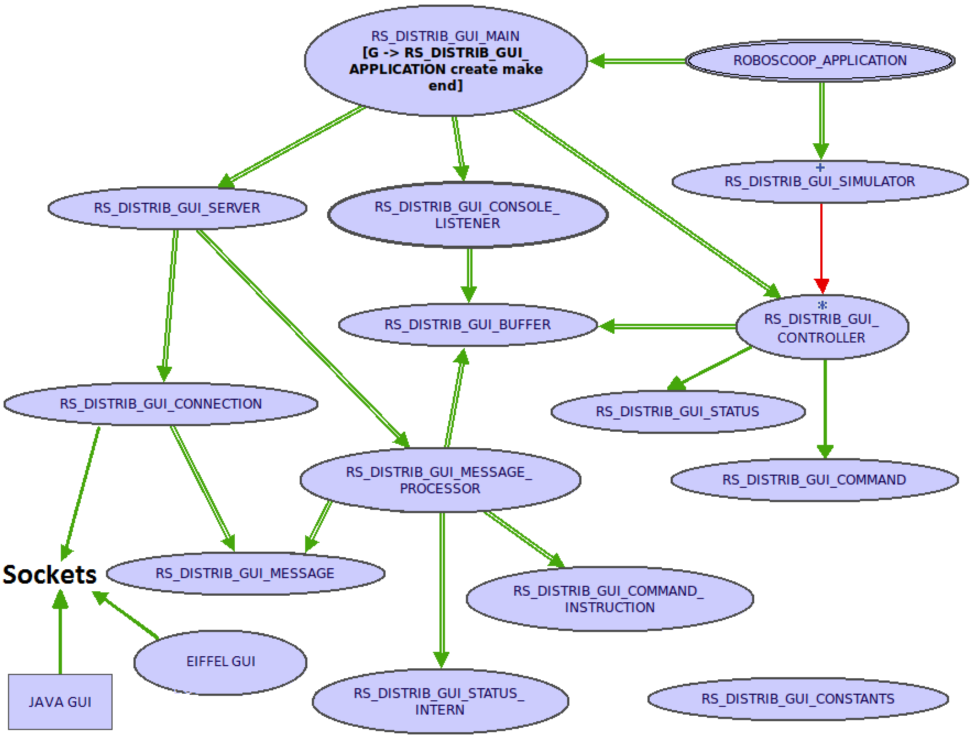

RS_DISTRIB_GUI_MAIN
[G -> RS_DISTRIB_GUI_APPLICATION create make end]
ROBOSCOOP_APPLICATION
RS_DISTRIB_GUI_SERVER
RS_DISTRIB_GUI_CONSOLE_LISTENER
RS_DISTRIB_GUI_SIMULATOR
RS_DISTRIB_GUI_BUFFER
RS_DISTRIB_GUI_CONTROLLER
RS_DISTRIB_GUI_CONNECTION
RS_DISTRIB_GUI_STATUS
RS_DISTRIB_GUI_MESSAGE_PROCESSOR
RS_DISTRIB_GUI_COMMAND
Sockets
RS_DISTRIB_GUI_MESSAGE
RS_DISTRIB_GUI_COMMAND_INSTRUCTION
EIFFEL GUI
JAVA GUI
RS_DISTRIB_GUI_STATUS_INTERN
RS_DISTRIB_GUI_CONSTANTS

Figure 1. A complete class diagram. For detailed information about all the classes consult the documentation chapter of the thesis.

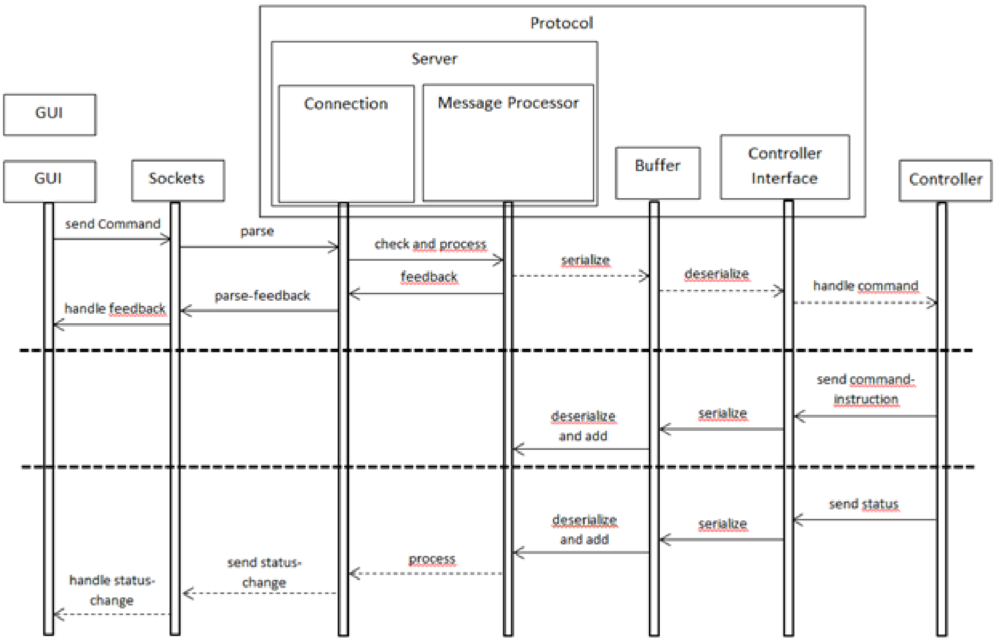


Figure 2. Runtime diagram of the most important communication types.

Chapter 4

Evaluation

In this chapter the capabilities of the protocol are discussed with help of two examples. The first one is a minimal example to indicate the complexity of the protocol, the second is a larger one which should simulate a real usage. Both controllers are only simulators and do not interact with any real robot.

4.1 Examples

To use the library the developer has to write two classes; the *CONTROLLER* and a *GUI*. Finally he has to create an instance of the *RS_DISTRIB_GUI_MAIN* class in his Roboscoop application. If the framework is used without a Roboscoop application, this instance is the only thing needed in the root class of the application. The generic parameter of the class determines the *CONTROLLER* used, while the arguments of the creation procedure define the ports and IP-address of the sockets.

The minimal example is discussed first.

The following class is an example for a root class when using the protocol without Roboscoop.

```
class
  EXAMPLE_APPLICATION
create
  make
feature
  make
    do
      create main.run (”84.75.135.127”, 2000, 8888)
    end
  main: RS_DISTRIB_GUI_MAIN [RS_DISTRIB_GUI_SIMPLE_SIMULATOR]
end
```

The controller needs to inherit from the *RS_DISTRIB_GUI_CONTROLLER* interface and implement the five deferred features.

The next class is a very simple controller. It simulates a robot which can support two commands, *start* and *stop*, with one status, *running*.

```
class
    RS_DISTRIB_GUI_SIMPLE_SIMULATOR
inherit
    RS_DISTRIB_GUI_CONTROLLER
create
    make
feature {NONE}
    at_create
            --initialize the global variable, no server needed.
        do
            create running.make (”running”, ”no”)
        end
    initialize
        local
            --initialize status and command instruction at the server
            command_instruction: RS_DISTRIB_GUI_COMMAND_INSTRUCTION
        do
            send_status (running)
            create command_instruction.make (”start”)
            command_instruction.allow_none
            send_command_instruction (command_instruction)
            create command_instruction.make (”stop”)
            command_instruction.allow_none
            send_command_instruction (command_instruction)
        end
    execute
            --There is no need to calculate something in this very simple Simulator.
        do
        end
    execute_every_time_interval
            --Send the status to the server
        do
            send_status (running)
        end
    handle_command (a_command: RS_DISTRIB_GUI_COMMAND)
            --Handle received commands from the GUI.
        do
            if a_command.name.is_equal (”start”) then
                running. set_value (”yes”)
            elseif a_command.name.is_equal (”stop”) then
                running. set_value (”no”)
            end
        end
    running: RS_DISTRIB_GUI_STATUS
end
```

The last part needed is a GUI. The *SIMPLE_GUI* is based on a “Graphics application, multi-platform, with EiffelVision 2” project from Eiffelstudio. It consists of a single button with which the simulated robot can be started or stopped. The state (running or not) of the robot is displayed in the middle of the button. The code for this GUI is located in the code section under *RS_DISTRIB_GUI_SIMPLE_GUI*

The other GUI-controller pair is capable of more.

The *CONTROLLER* simulates a robot which can accelerate, break and steer. Depending on the *COMMANDS* received from the GUI, the controller calculates the state of the robot and sends *STATUSES* to the server containing its x/y coordinates, speed, rotation speed and rotation angle. The code for this *CONTROLLER* is located in the code section under *RS_DISTRIB_GUI_SIMULATOR*.

The GUI (*figure 3*) is written in Java and consists of a map where the simulated position of the robot is visible and buttons to control this robot. The controller responds to the commands issued by pressing the buttons whereafter the GUI shows the movements of the robot. The GUI was written with the help of the Standard Widget Toolkit of Eclipse and can be found in the Code Section under *RS_DISTRIB_GUI_JAVA_GUI*.

4.2 Analysis

The first example should show that the use of the protocol was not overly complicated. The size and structure of the *SIMPLE_SIMULATOR* indicate this. The *SIMPLE_GUI* is bigger and more complicated, but this lies in the nature of *GUIs* and the template. Little of its complexity comes from the interaction with the protocol.

The second example should simulate a real usage of the protocol. Of course the classes are bigger than in the minimalistic example, but the complexity has not increased excessively. The simulated robot could be controlled in real-time, both on the same computer as well as in a local network.

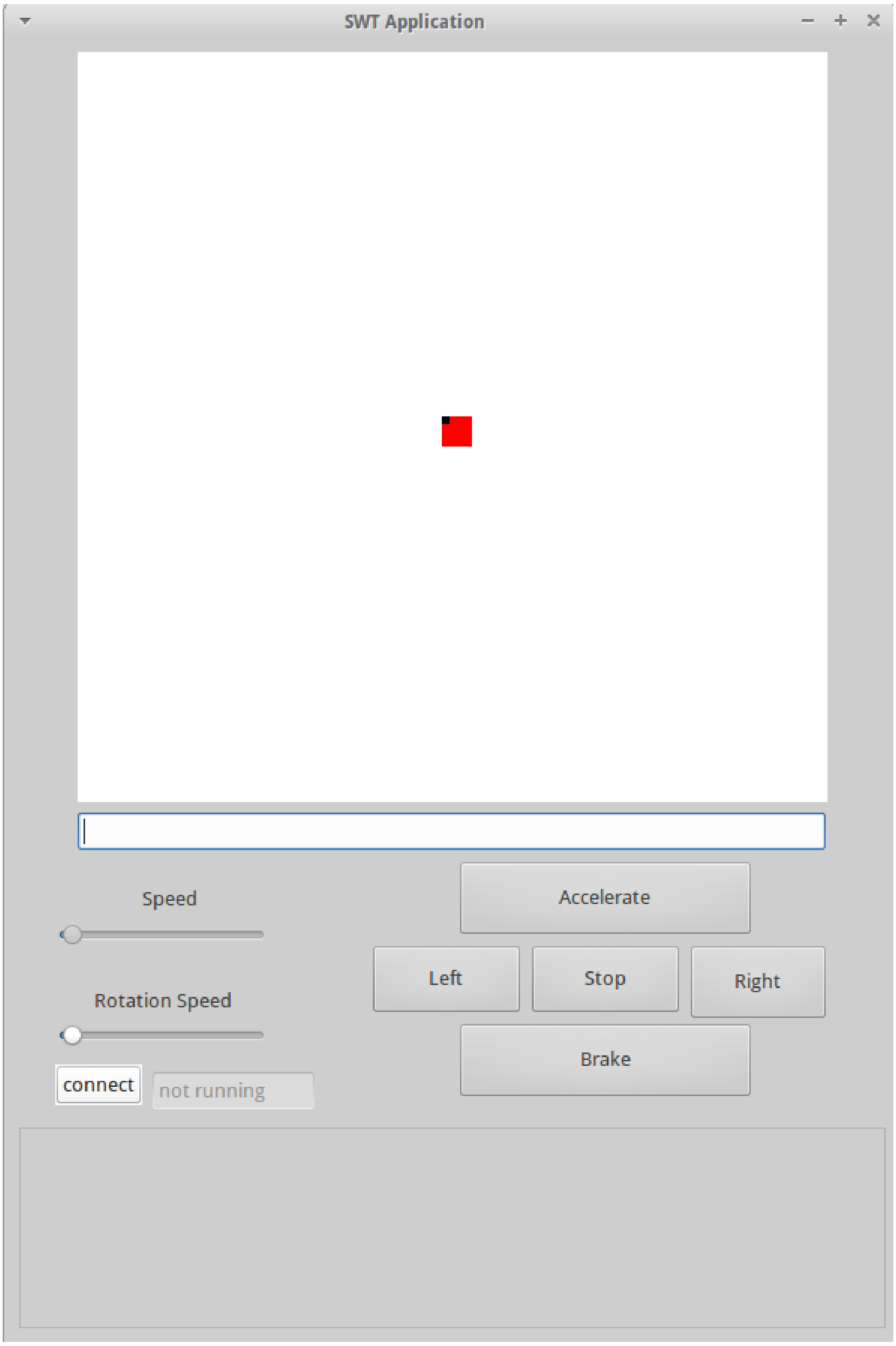


Figure 3. A picture of the example GUI. The red dot represents the robot while the small blue dot indicates the direction in which the robot is facing.

Chapter 5

Limitations and Future work

All planned features could be implemented with one exception: To make the usage of the protocol easier it was planned to automatically update the IP-address of the server. The retrieval of this information was not successful in Eiffel and the IP-address and port have to be assigned manually as a parameter at creation of the server.

All the testing of the protocol was done with simulated robots and with a single developer. To really capture the benefits and flaws of the protocol, testing with real robots and different developers should be done.

To be able to stop the execution of the server, a *CONSOLE_LISTENER* was implemented. Its only purpose is to listen to the ″stop″ command, but its structure could be used for much more, for example to configure the server at run-time which is not possible at this moment.

If a GUI only wants to request a *STATUS* once, it has to register for it and unregister immediately afterwards so as not to get further updates for this status. If this functionality is needed a lot, a "once" command could be added to the set of usable commands for the GUIs to automate this procedure.

Chapter 6

Results and Conclusion

The project resulted in a protocol to use with Roboscoop applications or as a standalone. A minimal example controller and GUI were created which show a not overly complicated setup of the protocol. A realistic controller and bigger GUI were also created to demonstrate a possible real use of the protocol. Testing on one computer and on a local network showed real time control of the simulated robot with the GUI and without crashes.

Almost all wanted features could be realized with the exception of an automated IP-address recognition. Some network changes might require a recompilation of the framework.

The tests with the examples went well but further evaluations with real robots and different developers will show more benefits and flaws of the protocol.

Appendix A

Interfaces

A.1 Application

To use the protocol, the (Roboscoop) application has to have an instance of the *MAIN* class with the desired *CONTROLLER* as generic parameter. The creation procedure *run* of the *MAIN* class has three arguments. The IP-address and port on which the stream socket is expected to connect and the port on which the datagram socket sends and listens for broadcasts.

A.2 Controller

A.2.1 Deferred Features

The controller has to be an Eiffel class which inherits from the deferred class RS_DISTRIB_GUI_Controller. The class has five deferred features, the rest of the features are frozen. A brief view over the deferred methods:

- *at_create* is executed in the creation procedure of the class. It has to be used because the creation procedure itself is frozen.
- *initialize* is executed before all following but after the server setup has finished. Initializations where the server is needed can be made in this feature.
- *execute* is executed every iteration of the loop as fast as specified in the *CONSTANTS* class.
- *execute_every_timeinterval* is executed every time interval which can be set at runtime. This can be used in order to prevent flooding of the network by only sending periodic updates to the GUI through the *SERVER*.

- *handle_command* is called when a *COMMAND* arrives from the GUI. In this feature the further process of the *COMMANDs* should be specified.

A.2.2 Helper Classes for Communication

To communicate with the GUIs through the *SERVER* the *CONTROLLER* uses three helper classes:

- The *STATUS* class is a simple one, which is used to send states of the robot to the *SERVER*, an example being the position or speed. It consists of a name string and a value string and has to be sent with the feature "send_status" from the deferred class. A sent *STATUS* with the same name as an old one is understood as update of the old *STATUS*.
- The *COMMAND* class is the equivalent to the status class but for the other direction. If a button is pressed on a GUI, the latter sends a command to the controller through the server. It consists of the name and argument string while also containing the id of the originating GUI if this should be needed.
- *COMMAND_INSTRUCTIONs* are used to restrict the kind of *COMMANDs* the *SERVER* accepts from the GUIs. The name string of the class determines the exact name a *COMMAND* can poses. If there is no *COMMAND_INSTRUCTION* with a matching name, the server sends back an error message to the GUI and does not forward the *COMMAND* to the *CONTROLLER*.

  For the argument of the *COMMAND* there are many possibilities. The *CONTROLLER* can allow strings, integers, doubles or none. It can further restrict the argument by reducing the integer argument to a range or the string argument to a set of predefined strings. As a last option multiple arguments can be allowed. The same holds for the arguments. If there is a command sent with non-matching arguments, it is not forwarded and an error message is sent back.

A.3 GUI

The GUI communicates with a subset of JSON through sockets to the *SERVER* . Since the protocol only handles the JSON type ″string″, the quotation marks can be omitted. This makes working with JSON strings for the GUI easier. The only JSON the server accepts are command_name and _argument pairs. Examples of accepted JSON packets: ′name:argument′, ′name:″argument″′, ′name:argument1,″argument2″′,
′name1:argument1, name2:argument2′

This is what allows the GUI to be written in any language which enables socket communication.

A.3.1 Datagram Socket

The datagram socket is only used to gain connection information from the *SERVER* to know where to connect to the stream socket. The *SERVER* will listen to a ″request″ command on the port specified at creation of the server with the arguments ″address″ or ″port″ or both. The response will be a JSON object with ″address″ as its name and the IP-address as argument or the equivalent with port or both.

A.3.2 Stream Socket

The stream socket is the main channel where the GUI communicates with the *SERVER*. The *SERVER* accepts command_name and value pairs. The help *COMMAND* can be sent to the socket to request all possible commands the server accepts. If the help *COMMAND* has an argument, only information about the *COMMAND* with the name specified in the argument is sent back. A set of *COMMANDs* which is specified in the *CONTROLLER* exists as well as a set of static *COMMANDs* which are used by the *SERVER*. These are:

- help

  The *SERVER* sends back information about all *COMMANDs* which are accepted. If the optional argument is present, only information about the *COMMAND* specified in the argument is sent.

- register

  The *STATUSES* specified in the argument are registered on the *SERVER* to receive updates if one of them changes.

- unregister

  A previously registered *STATUS* specified in the argument is unregistered again.

- safe

  Saves the set of registered *STATUSes* to the slot named after the argument string on the *SERVER*.

- load

  Loads the set of registered *STATUSes* from the slot specified in the argument.

- get_user_id

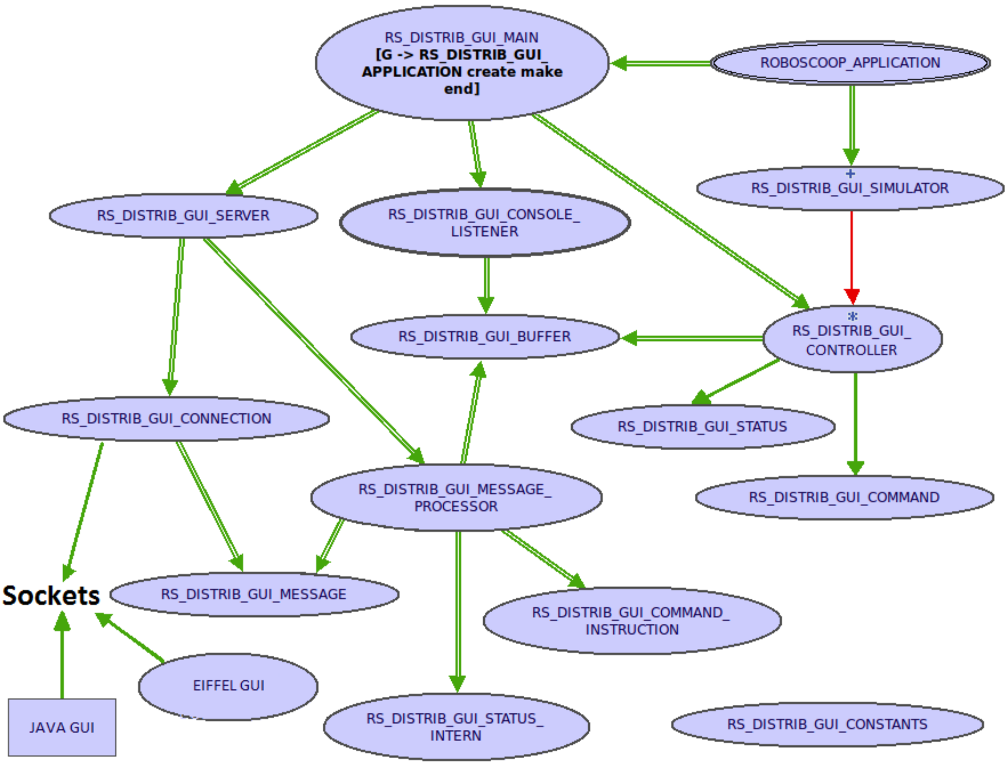
  The *SERVER* sends back the user id of the GUI. This could be useful when debugging a system with multiple GUIs in order to know from which GUI the *CONTROLLER* receives *MESSAGEs*.

Appendix B

Documentation

The design of the framework is described in this chapter in detail. All classes and the most important features are listed by name.

B.1 Overall Structure


RS_DISTRIB_GUI_MAIN
[G -> RS_DISTRIB_GUI_APPLICATION create make end]
ROBOSCOOP_APPLICATION
+
RS_DISTRIB_GUI_SIMULATOR
RS_DISTRIB_GUI_SERVER
RS_DISTRIB_GUI_CONSOLE_LISTENER
RS_DISTRIB_GUI_BUFFER
*
RS_DISTRIB_GUI_CONTROLLER
RS_DISTRIB_GUI_CONNECTION
RS_DISTRIB_GUI_STATUS
RS_DISTRIB_GUI_MESSAGE_PROCESSOR
RS_DISTRIB_GUI_COMMAND
Sockets
RS_DISTRIB_GUI_MESSAGE
RS_DISTRIB_GUI_COMMAND_INSTRUCTION
EIFFEL GUI
JAVA GUI
RS_DISTRIB_GUI_STATUS_INTERN
RS_DISTRIB_GUI_CONSTANTS

The framework is called *RS_DISTRIB_GUI* and in this documentation all classes, which are named *RS_DISTRIB_GUI_EXAMPLE*, are referred to as *EXAMPLE*.

The *MAIN* is the heart of the framework and consists of separate instances of the thee parts, the *SERVER*, the *CONTROLLER* and the *CONSOLE_LISTENER* . To use the framework the Application has to have an instance of the *MAIN* class. The three parts communicate via a separate *BUFFER* using helper classes (*COMMAND_INSTRUCTION*, *COMMAND*, *STATUS*, *STATUS_INTERN*) which get serialized to become separate. The *CONSOLE_LISTENER* merely listens for the "stop" string from the console and thus needs no helper classes.

The *SERVER* consists of two parts, the *CONNECTION* which is responsible for socket communication with the *GUIs*) and the *MESSAGE_PROCESSOR* which analyses the received *MESSAGEs* from the sockets and decides what to do with them, like sending them to the *CONTROLLER* or processing them. The *CONNECTION* can handle multiple different *GUIs* via the sockets.

The *GUIs* can be written in any language which allows socket communication.

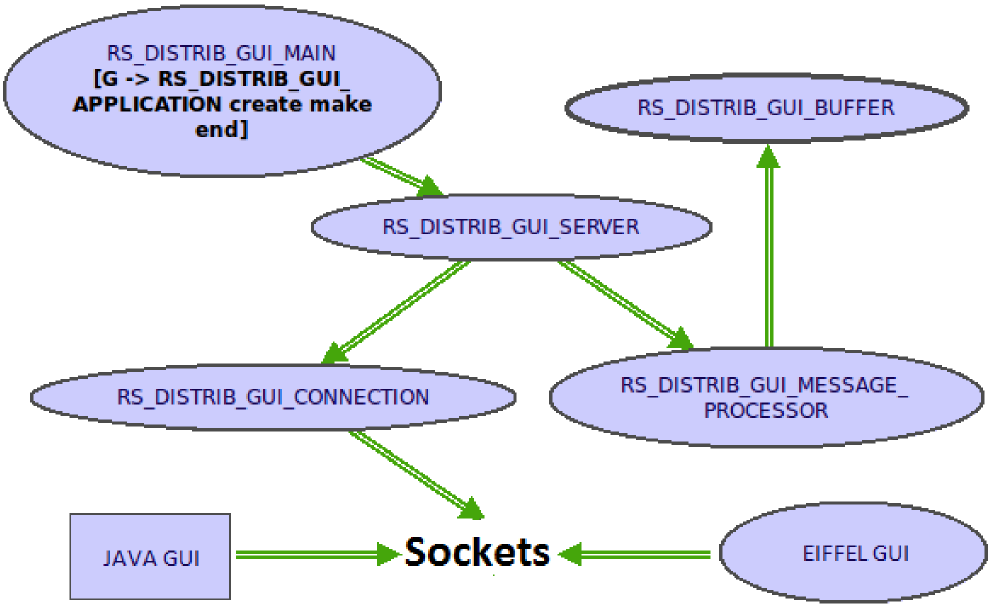
The *CONTROLLER* is a deferred class to help the concrete *CONTROLLER* with communication and parallel execution. The concrete *CONTROLLER* is used to control the robot and send *STATUS* updates to the *SERVER*. The concrete *CONTROLLER* has to be written in Eiffel since it needs to inherit from an Eiffel class.

The last part of the framework are the static *CONSTANTS* with configurable values for performance, communication, parsing and default sizes.

B.2 MAIN and Roboscoop_Application

To run the framework, the program needs to have an instance of *MAIN* with a concrete *CONTROLLER* as generic parameter and execute the create procedure *run* with three arguments: The IP-address and port of the stream socket and the port of the datagram socket. If no code is needed around the framework, *Roboscoop_Application*'s *make* should be used as root.

B.3 SERVER



The *SERVER* is responsible for the communication between the *GUIs* through sockets and the *CONTROLLER* via *BUFFER*. It also processes and triggers *MESSAGEs* from and to *GUI* and *CONTROLLER*.

To help fulfill these tasks the class has two helper classes, the *CONNECTION* and the *MESSAGE_PROCESSOR*.

Important features:

- *run*

  This is the heart-feature of the *SERVER*. It consists of the basic loop of which cycles through its other features of the *SERVER*

- *listen_to_udp*

  The *SERVER* asks the *CONNECTION* if a broadcast has been detected with the datagram socket and if so, lets this *MESSAGE* be processed by the *MESSAGE_PROCESSOR* which sends an answer back to the *CONNECTION* to broadcast through said socket.

- *listen_to_connection_changes*

  The *SERVER* asks the *CONNECTION* if there are any *GUIs* wanting to connect to a stream socket and if so, lets the *CONNECTION* connect the *GUIs* with one.

- *listen_to_tcp*

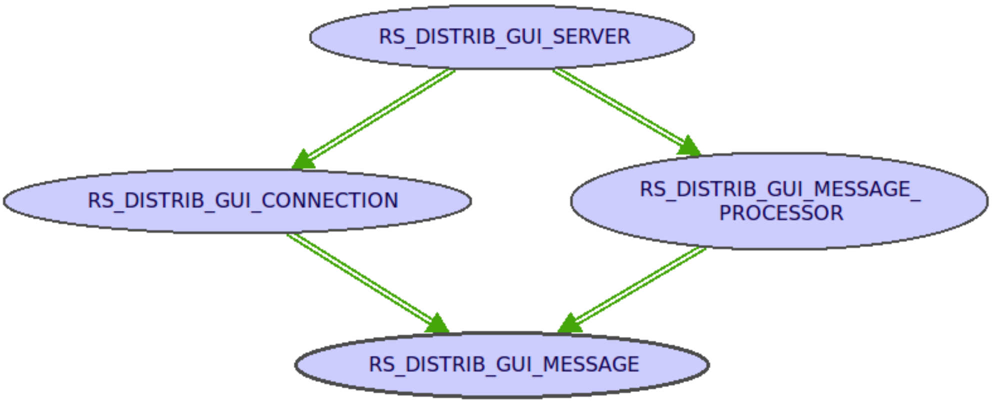
The *SERVER* asks the *CONNECTION* if there are any *MESSAGEs* pending on the Stream-Sockets which were connected to *GUIs* and if so, lets this *MESSAGEs* be processed by the *MESSAGE_PROCESSOR* which sends an answer back to the *CONNECTION* to send back to the Stream-Socket where the *MESSAGEs* originated from.

Broken stream socket connections are cleaned up here.

- *listen_to_buffer*

  The *SERVER* asks the *BUFFER* if there are any changed *STATUSes* the *GUIs* are registered for and sends those to the *CONNECTION* to send to the *GUIs* trough stream socket .

B.4 CONNECTION



The *CONNECTION* is used by the *SERVER* to handle the communication with the sockets. The class reads broadcasted *MESSAGEs* and broadcasts *MESSAGEs* from the *MESSAGE_PROCESSOR* through the datagram socket.

Furthermore the *CONNECTION* also accepts stream sockets from *GUIs* and sends/receives *MESSAGEs* through them.

Because of race-conditions when a *GUI* is crashing, some features have empty rescue clause.

Important features:

- *read_from_udp*

  This feature reads the broadcasted *MESSAGE* from the datagram socket and parses it to a JSON object.

- *send_to_udp*

  The argument, a *JSON* object, gets serialized to a string and then broadcasted through the datagram socket.

- *accept_tcp_socket*

  This feature tries to accept waiting stream sockets from *GUIs*. If there are more *GUIs* waiting and accepted than specified in the *CONSTANTS* the waiting socket gets connected to an overflow socket and an error message gets sent back.

- *read_from_tcp*

  In comparison to *read_from_udp* this feature takes a user id as parameter and only reads the *MESSAGE* associated to the id since there is one socket per *GUI*.

- *send_to_tcp*

  This feature tries to send a *MESSAGE* to a specific user. To enable this feature the user has to be connected to the stream socket.

B.5 MESSAGE

The *MESSAGE* is used to parse, process and answer requests from the sockets. It has a JSON object with own parser and also carries the id of the user associated with the *MESSAGE*.

Important features:

- *parse*

  A raw string gets parsed to a JSON object. Since the framework only accepts very specific *MESSAGEs*, the parser is very small. If a parse error occurs, a error notice gets written to the resulting JSON object of the *MESSAGE*.

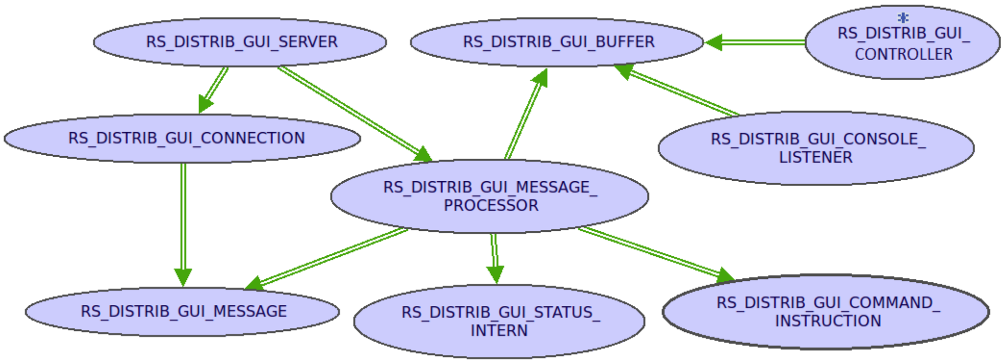
- *put*, *add*, *get* , *remove*

  These are the interaction features with the JSON object respectively JSON key-value pairs. *Put* will overwrite a value while *add* appends the new value to the old one. *Get* will return the value for a key and if no pair with requested key is found an empty string. *Remove* deletes a key and all its values from the object.

- *to_string*

  Beside the use to print JSON objects, this feature is also used to serialize the objects so that they can be sent back to the sockets.

B.6 MESSAGE_PROCESSOR


RS_DISTRIB_GUI_SERVER
RS_DISTRIB_GUI_BUFFER
*
RS_DISTRIB_GUI_CONTROLLER
RS_DISTRIB_GUI_CONNECTION
RS_DISTRIB_GUI_CONSOLE_LISTENER
RS_DISTRIB_GUI_MESSAGE_PROCESSOR
RS_DISTRIB_GUI_MESSAGE
RS_DISTRIB_GUI_STATUS_INTERN
RS_DISTRIB_GUI_COMMAND_INSTRUCTION

The *MESSAGE_PROCESSOR* is processing *MESSAGEs* received from the *CONNECTION*. It decides if the *MESSAGE* is aimed at the *SERVER* or at the *CONTROLLER* and writes answers to the *MESSAGEs* which get sent back to the *GUIs*.

It also listens to *MESSAGEs* from the *CONTROLLER* via the *Buffer* and handles accordingly.

Important features:

- *process_tcp* , *process_udp*

  This is the entry point for a *MESSAGE* from the *CONNECTION*. First the MESSAGE gets checked for errors (*verify*) and if there are none, decided what to do with it (*handle_MESSAGE*) and last there is an answer written which gets send back to the *CONNECTION* via the socket (*answer_message*).

  Since the capability of the udp part in this framework is very limited. It's not possible to alter the state of the *SERVER* via udp-Socket and the *handle_message* part is omitted.

- *verify*

  This feature is used by the process features to check the satisfaction of the constraints (*COMMAND_INSTRUCTION*) the *CONTROLLER* or *SERVER* has defined. It will write an error message to the *MESSAGE* if something is wrong and else write an "ok" string.

  The feature is split up into multiple smaller ones for better maintenance.

- *handle_message_tcp*

  The *process* feature uses this feature to decide what to do with the *MESSAGE*. If the *MESSAGE* contains a *COMMAND* aimed for the

SERVER, it gets executed and deleted from the *MESSAGE*. If it contains *MESSAGEs* aimed for the *CONTROLLER*, they get sent to the *CONTROLLER* via the *BUFFER*.

- *answer_message_tcp* , *answer_message_udp*

  The answer to the *GUI* is formed here. If there was an error the answer contains an error message. If there was a help *COMMAND* the answer will consist of a help MESSAGE with all the possible *COMMANDs* and their arguments. In the normal use case the answer *MESSAGE* is just an "ok"-String.

- *check_buffer*

  Other than with *MESSAGEs* from the sockets, the class has to actively look for MESSAGEs from the *CONTROLLER*. The MESSAGE from the *BUFFER* can either be a *STATUS* or a *COMMAND_INSTRUCTION* which will be added to the SERVER using *add_command* and *add_status* .

- *add_command_instruction*

  Adds a *COMMAND_INSTRUCTION* to the set of usable *COMMANDs* . Meta *COMMAND* names are not allowed (*unregister* , *register* , *load* , *safe* , *get_user_id*) and if there already is another *COMMAND_INSTRUCTION* with the same name, the old one gets overwritten.

- *add_status*

  Adds a *STATUS* to the registrable *STATUSes* of each user. If the *STATUS* already existed, the old value gets overwritten.

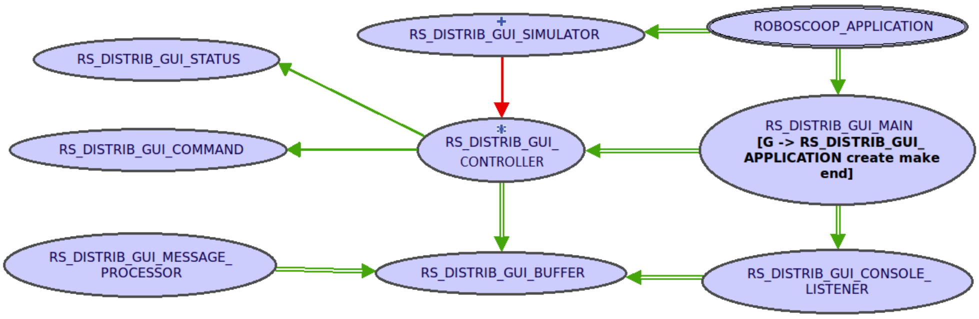
- *register_status* , *unregister_status*

  Each user who is connected to a stream socket can register and unregister *STATUSes* which values will get sent to the *GUIs* whenever they change. Different *GUIs* can have different *STATUSes* registered. Registering a registered *STATUS* or unregistering an unregistered *STATUS* will result in an error notice in the answer *MESSAGE*.

- *safe_state* , *load_state*

  The set of registered *STATUSes* can be saved to be restored later for example because of a disconnection or multiple *GUIs* which want to synchronize.

B.7 CONTROLLER



The *CONTROLLER* is a deferred class to be implemented by the user when he wants to write an CONTROLLER running on a robot using this framework. The class handles communication with the framework and parallel execution of various methods.

Important features:

- *send_status* , *send_command_instruction*

  Send a *STATUS* or *COMMAND_INSTRUCTION* to the *SERVER* through the *BUFFER* and allows the user to be able to only work with not **separate** objects.

- *run*

  This feature runs the basic loop of the class which cycles through the other important features of the class. How fast the loop runs can be configured in the CONSTANTS.

- *check_buffer*

  Is executed every loop iteration and checks the *BUFFER* for *MESSAGE* from the *SERVER*. If there is a *MESSAGE*, *handle_command* is executed with the *MESSAGE* as argument.

- *initialize*

  This deferred method is executed once before starting the loop but after the setup of the structure of the framework and is used to provide a pseudo creation procedure where the user already can communicate with the *SERVER*.

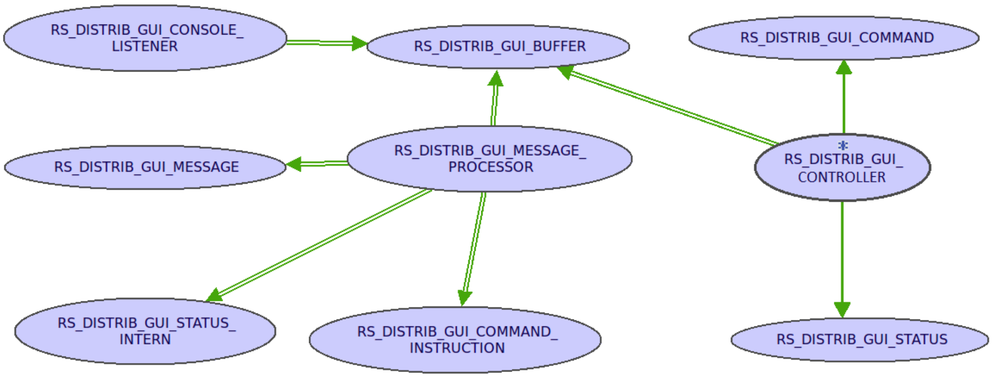
- *execute* , *execute_every_time_interval* , *set_time_interval*

  These two deferred execute features get executed periodically to allow for calculations to be made or *STATUS* updates. *Execute_every_time_interval* is only executed at most the *time_interval* specified in *set_time_interval* with a default of 200 ms.This can, for example, be used to prevent flooding of a network.

- *handle_command*

  Every time a *COMMAND* is sent from the *SERVER* this deferred feature is executed with the *COMMAND* as argument. The user can decide here what to do with the *COMMAND*.

B.8 BUFFER


RS_DISTRIB_GUI_CONSOLE_ LISTENER
RS_DISTRIB_GUI_BUFFER
RS_DISTRIB_GUI_COMMAND
RS_DISTRIB_GUI_MESSAGE
RS_DISTRIB_GUI_MESSAGE_ PROCESSOR
* RS_DISTRIB_GUI_ CONTROLLER
RS_DISTRIB_GUI_STATUS_ INTERN
RS_DISTRIB_GUI_COMMAND_ INSTRUCTION
RS_DISTRIB_GUI_STATUS

The *BUFFER* is used for the communication between *SERVER* and *CON—TROLLER*. All *MESSAGEs* get serialized to a string and put on an *Arrayed_ Queue*. Each direction has an own queue, getter and setter.

Important features:

- *application_values* , *server_values*

  The queues to store the serialized objects.

- *set_server* , *get_server* , *has_server*

  The access features for *MESSAGEs* sent from *SERVER* to *CONTROLLER* .

- *set_application* , *get_application* , *has_application*

  The access features for *MESSAGEs* sent from *CONTROLLER* to *SERVER* .

B.9 STATUS and STATUS_INTERN

The classes used to send data from *CONTROLLER* through the *SERVER* to the *GUIs*.The *STATUS* class is only used to for the *CONTROLLER* to send data to the *SERVER* while the *STATUS_INTERN* class is then used by the *SERVER* to store the data and decide when to send it to the *GUIs* (when it has changed). Two classes are used to hide complexity from the user.

Important features:

- *name, value*

  The identifier and content of the data.

- *changed*

  The boolean the *STATUS_INTERN* uses to see if data has changed. Is set when *set_value* , *set_changed* or *set_unchanged* is called.

B.10 COMMAND

A *COMMAND* is used when a *GUI* sends a MESSAGE to the *CONTROLLER* . What kind of *COMMANDs* and arguments are allowed is restricted by the *CONTROLLER* with *COMMAND_INSTRUCTIONs*.

Important features:

- *name, argument*

  The data of the command.

B.11 COMMAND_INSTRUCTION

A *COMMAND_INSTRUCTION* is used to restrict the possible *COMMANDs* that are accepted by the *SERVER* from the *GUI*. The name of a *COMMAND* has to be exactly the name of an existing *COMMAND_INSTRUCTION* and the arguments have to follow the specified guideline.

Important features:

- *allow_∗*

  Used by the *CONTROLLER* to say what kind of argument is allowed. This can be String, Integer, Double, Range or None paired with *allow_multiple* to allow more than one argument.

- *∗_allowed*

  Request what kind of arguments are allowed.

B.12 CONSTANTS

This static class contains all CONSTANTS used by the framework. Some of them have to be adapted to secure proper running, others can be changed if needed.

- The JSON constants are used by the *GUIs* to talk to the *SERVER*. Changing them can cause problems with existing *GUIs*.

- The command constants appear in error and help *MESSAGEs* from the *SERVER* to the *GUI* and are display only.
- The performance constants specify the wait times between each iteration of the three MAIN loops. They can be changed if there are performance issues.

Appendix C

Code

C.1 RS_DISTRIB_GUI

C.1.1 ROBOSCOOP_APPLICATION

```
note
    description : ”Entry Point of the Framework”

class
   ROBOSCOOP_APPLICATION
create
   make

feature
   make
      do
         create main.run (”84.75.135.127”, 2000, 8888)
      end
   main: RS_DISTRIB_GUI_MAIN [RS_DISTRIB_GUI_SIMPLE_SIMULATOR]
end
```

C.1.2 RS_DISTRIB_GUI_BUFFER

```
note
    description :
      ”A buffer used to communicate between Server, Application and Console_Listener.”

class
   RS_DISTRIB_GUI_BUFFER

create
   make

feature -- Access

   make
         --create with default sizes (overflow is handled by datastructure).
      do
      create server_values .make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
      create application_values .make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
      stopped := false
    end

  stop
      --stop the execution. Is propagated to Server and Application.
    do
      stopped := true
    end

  is_stopped : BOOLEAN
      --is the execution stopped?
    do
      Result := stopped
    end

feature -- Access Server

  set_server (a_value: separate STRING)
      --insert a value into the server buffer.
    do
      server_values .extend (create {STRING}.make_from_separate (a_value))
    end

  get_server : STRING
      --read a value from the server buffer.
    require
      has_server_element
    do
      Result := server_values .item
      server_values .remove
    end
has_server_element : BOOLEAN
      --has the server buffer some elements?
    do
      Result := server_values .count > 0
    end

feature -- Access Application

  set_application (a_value: separate STRING)
      --insert a value into the application buffer.
    do
      application_values .extend (create {STRING}.make_from_separate (a_value))
    end

  get_application : STRING
      --read a value from the application buffer.
    require
      has_application_element
    do
      Result := application_values .item
      application_values .remove
    end

  has_application_element : BOOLEAN
      --has the application buffer some elements?
    do
      Result := application_values .count > 0
    end

feature {NONE} -- Global Variables

  application_values : ARRAYED_QUEUE[STRING]
      --values sent from application to server.

  server_values : ARRAYED_QUEUE[STRING]
      --values sent from server to application.

  stopped: BOOLEAN
      --is the execution stopped?
end
```

C.1.3 RS_DISTRIB_GUI_COMMAND

```
note
  description :
    "A command which is sent from the server to the application mostly triggered by a
        message from the tcp-socket."

class
  RS_DISTRIB_GUI_COMMAND

create
  make, make_from_serialisation

feature -- Access

  make (a_name: STRING; a_argument: STRING; a_user_id: INTEGER)
      --create.
    do
      name := a_name
      argument := a_argument
      user_id := a_user_id
    end

  make_from_serialisation ( a_serialisation : STRING)
      --create from serialisation, used to handle separate objects.
    do
      name := a_serialisation .split (':') .at (1)
      argument := a_serialisation .split (':') .at (2)
      user_id := a_serialisation .split (':') .at (3). to_integer
    end

  serialize : STRING
      --serialize object to make a separate into a non separate.
    do
```

```
      Result := name + ":" + argument + ":" + user_id .out
    end

  name: STRING
      --name of the command.

  argument: STRING
      --argument of the command.

  user_id : INTEGER
      --id of user who sent the command. This id might change if the user reconnects.

end
```

C.1.4 RS_DISTRIB_GUI_COMMAND_INSTRUCTION

```
note
  description :
    "A set of constraints the Application can set for Commands. The Server will check
         these constraints and only send valid commands to the application."

class
  RS_DISTRIB_GUI_COMMAND_INSTRUCTION

create
  make,  make_from_serialisation

feature -- Access

  make (a_name: STRING)
      --create.
    do
      name := a_name.as_lower
      create custom.make
      argument_allowed := {RS_DISTRIB_GUI_CONSTANTS}.none_allowed
    ensure
       no_forbidden_characters : not name.has (',') and not name.has (':')
    end

   make_from_serialisation  ( a_string : STRING)
      --create from serialisation, used to handle separate objects.
    require
       a_string . starts_with  ("c")
    do
      create custom.make
      name := a_string . split  (':') .at (2)
      argument_allowed := a_string . split  (':') .at (3)
      lower := a_string . split  (':') .at (4) . split  (',') .at (1) . to_integer
      upper := a_string . split  (':') .at (4) . split  (',') .at (2) . to_integer
       make_custom_from_serialisation  ( a_string . split  (':') .at (5) )
      multiple_allowed  := a_string . split  (':') .at (6) . to_boolean
    end

   serialize : STRING
```

```
    --serialize object to make a separate into a non separate.
  do
    Result := "c:" + name.out + ":" + argument_allowed + ":" + lower.out + "," + upper.
       out + ":" + serialize_custom + ":" + multiple_allowed.out
  end

serialize_custom : STRING
    --serialize the custom values.
  local
    l_string : STRING
  do
    l_string := ""
    across custom as element loop
      if l_string.count > 0 then
        l_string.append (",")
      end
      l_string.append (element.item)
    end
    Result := l_string
  end

make_custom_from_serialisation (a_string : STRING)
    --create custom strings from a serialisation.
  do
    if a_string.count > 0 then
      across a_string.split (',') as element loop
      add_custom_string (element.item)
      end
    end
  end

to_string : STRING
    --make command instruction to string to print.
  do
    if to_string_arguments.is_equal ("") then
      Result := name.out
    else
      Result := name.out + ":" + to_string_arguments.out.as_upper
    end
  end

to_string_arguments : STRING
    --make arguments to string to print.
  local
    l_result : STRING
  do
    l_result := argument_allowed.out
    if argument_allowed.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.range_allowed) then
      l_result.append ("[" + lower.out + "-" + upper.out + "]")
    elseif argument_allowed.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.custom_allowed)
        then
      l_result.append ("{" + serialize_custom + "}")
    end
    if multiple_allowed then
```

```
        l_result .append ("*")
      end
      Result := l_result
    end

  has_custom_string (a_string : STRING): BOOLEAN
      --is a specific string allowed as argument?
    do
      Result := across custom as l_custom some l_custom.item. is_equal (a_string ) end
    end

  name: STRING
      --name of the command.

  multiple_allowed : BOOLEAN
      --are multiple arguments allowed?

  lower,upper: INTEGER
      --boundaries (including) if a range of integers is allowed as arguments.

  custom: LINKED_LIST[STRING]
      --custom strings if custom strings are allowed as values.

  argument_allowed: STRING
      --what kind of arguent is allowed.

feature -- Basic Features

  allow_string
      -- allow strings as arguments.
    do
      argument_allowed := {RS_DISTRIB_GUI_CONSTANTS}.string_allowed
    end

  allow_integer
      --allow integers as arguments.
    do
      argument_allowed := {RS_DISTRIB_GUI_CONSTANTS}.integer_allowed
    end

  allow_double
      --allow integers as arguments.
    do
      argument_allowed := {RS_DISTRIB_GUI_CONSTANTS}.double_allowed
    end

  allow_range (a_lower: INTEGER; a_upper: INTEGER)
      --allow a range of integers as arguments.
    do
      argument_allowed := {RS_DISTRIB_GUI_CONSTANTS}.range_allowed
      lower := a_lower
      upper := a_upper
    end
```

```
allow_none
      --allow no arguments.
   do
      argument_allowed := {RS_DISTRIB_GUI_CONSTANTS}.none_allowed
   end

allow_custom_strings (a_custom_strings: LINKED_LIST[STRING])
      --allow custom strings as arguments
   do
      argument_allowed := {RS_DISTRIB_GUI_CONSTANTS}.custom_allowed
      across a_custom_strings as l_one_string loop
         l_one_string .item. to_lower
      end
      custom := a_custom_strings
   end

allow_multiple
      --allow multiple arguments. This is used in combination with another argument
         restriction and false by default
   do
      multiple_allowed := true
   end

integer_allowed : BOOLEAN
      --are only integer arguments allowed?
   do
      Result := argument_allowed. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.integer_allowed
         )
   end

range_allowed: BOOLEAN
      --are only integer arguments in a specific range allowed?
   do
      Result := argument_allowed. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.range_allowed)
   end

none_allowed: BOOLEAN
      --are no arguments allowed?
   do
      Result := argument_allowed. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.none_allowed)
   end

custom_allowed: BOOLEAN
      --are custom strings arguments allowed?
   do
      Result := argument_allowed. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.custom_allowed
         )
   end

string_allowed : BOOLEAN
      --are string arguments allowed?
   do
      Result := argument_allowed. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.string_allowed)
```

```
  end

 add_custom_string (a_string: STRING)
     --add a string to the custom stings allowed as arguments.
  require
     string_does_already_exist : not has_custom_string(a_string)
    custom_allowed: argument_allowed.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.
         custom_allowed)
  do
    custom.extend (a_string)
  end

 remove_custom_string (a_string: STRING)
     --remove a string from the custom strings allowed as arguments.
  require
     string_does_not_exist : has_custom_string(a_string)
    custom_allowed: argument_allowed.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.
         custom_allowed)
  local
    i: INTEGER
  do
    from
      i := 1
    until
      not custom.valid_index (i)
    loop
      if custom.at (i).is_equal (a_string) then
        custom.go_i_th (i)
        custom.remove
      end
      i := i + 1
    end
  end

end
```

C.1.5 RS_DISTRIB_GUI_CONNECTION

```
note
  description :
   "A class to handle udp broadcasts and connect users to tcp sockets."

class
 RS_DISTRIB_GUI_CONNECTION

create
 make

feature {ANY} -- Access

 make (a_address: STRING; a_stream_socket_port: INTEGER; a_datagram_socket_port:
     INTEGER)
     --create.
  do
```

```
      host_ip_address := a_address
      stream_socket_port := a_stream_socket_port
      datagram_socket_port := a_datagram_socket_port
      create tcp_message. make_filled (create {RS_DISTRIB_GUI_MESSAGE}.make(-1), 1, {
          RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections)
      create accepted_sockets . make_filled (create {NETWORK_STREAM_SOCKET}.make, 1,
          {RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections)
      create message_already_read . make_filled (true, 1, {RS_DISTRIB_GUI_CONSTANTS}.
          max_number_of_connections)
      create user_connected_tcp . make_filled (false, 1, {RS_DISTRIB_GUI_CONSTANTS}.
          max_number_of_connections)
      create overflow_socket .make
    end

  get_address : STRING
      --should return address of machine but does only return localhost right now.
    do
      Result := host_ip_address
    end

  get_port : STRING
      --return port of tcp socket.
    do
      Result := get_tcp_socket .port.out
    end

  cleanup
      --cleanup socket connection after execution.
    do
      get_tcp_socket .cleanup
      get_udp_socket .cleanup
    rescue
    end

  message_already_read : ARRAY[BOOLEAN]

feature {ANY} --UDP Features

  is_ready_to_read_udp : BOOLEAN
      --is there data to read on the udp socket?
    do
      Result := get_udp_socket . is_readable
    end

  read_from_udp: RS_DISTRIB_GUI_MESSAGE
      --read data from udp socket and parse to JSON Object.
    local
      l_message: RS_DISTRIB_GUI_MESSAGE
      l_raw_message: PACKET
    do
      l_raw_message := get_udp_socket . received ({RS_DISTRIB_GUI_CONSTANTS}.
          max_packet_size, 0)
      create l_message.make_from_packet (l_raw_message, 0)
      Result := l_message
    end

  send_to_udp (a_message: STRING)
      --broadcast a message via the udp socket.
    local
      l_raw_response : PACKET
      i: INTEGER
    do
      debug ("connection")
        print ("udp send:%N" + a_message + "%N%N")
      end
      a_message.append (",eof")
      create l_raw_response .make (a_message.count)
      From
        i := 0
      until
        i >= a_message.count
      loop
        l_raw_response .at (i) := a_message.at (i+1)
        i := i + 1
      end
      get_udp_socket .send ( l_raw_response , 0)
    end

feature {ANY} --TCP Features

  accept_tcp_socket
      --listen for accepting clients .
    local
      l_user_id : INTEGER
    do
      get_tcp_socket .accept
      if attached get_tcp_socket .accepted as accepted_socket then
        l_user_id := get_unused_user_id
        accepted_socket . set_blocking
        if l_user_id = -1 then
          overflow_socket := accepted_socket
          overflow_socket .putstring ("Maximum connections reached")
          overflow_socket .put_new_line
          debug("connection")
            print ("Tried to connect user but maximum connections reached.")
          end
        else
          accepted_sockets [ l_user_id ] := accepted_socket
          user_connected_tcp [ l_user_id ] := true
          debug ("connection")
            print ("Connected user: " + l_user_id .out + "%N")
          end
        end
      end
    end

  get_unused_user_id : INTEGER
      --get the lowest user id with no open connection.
    local
      i: INTEGER
      l_found: BOOLEAN
    do
      Result := -1
      from
        i := 1
        l_found := false
      until
        l_found or i > {RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections
      loop
        if not user_connected_tcp [i] then
          l_found := true
          Result := i
        else
          i := i + 1
        end
      end
    end

  get_user_ids : LINKED_LIST[INTEGER]
      --get all user ids with open connections.
    local
      l_user_ids : LINKED_LIST[INTEGER]
      i: INTEGER
    do
      create l_user_ids .make
      from
        i := 1
      until
        i > {RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections
      loop
        if user_connected_tcp [i] then
          l_user_ids .extend (i)
        end
        i := i + 1
      end
      Result := l_user_ids
    end

  is_ready_to_read_tcp (a_user_id : INTEGER): BOOLEAN
      --has socket from user id data to read, if yes write it to message buffer.
    do
      Result := false
      if get_accepted_tcp_socket (a_user_id ). is_open_read and get_accepted_tcp_socket (
          a_user_id ). is_readable then
        get_accepted_tcp_socket (a_user_id ). read_line
        if attached get_accepted_tcp_socket (a_user_id ). last_string as l_raw_message then
          if l_raw_message.count > 0 then
            message_already_read [a_user_id ] := false
            tcp_message[a_user_id ] := create {RS_DISTRIB_GUI_MESSAGE}.
                make_from_string (l_raw_message, a_user_id)
            Result := true
          end
        end
      end
    rescue
    end

  read_from_tcp ( a_user_id : INTEGER): RS_DISTRIB_GUI_MESSAGE
      --read message from buffer.
    require
      message_already_read [ a_user_id ] = false
    do
      debug ("connection")
        print ("Message from user: "+ a_user_id.out + "%N" + tcp_message [a_user_id].
            to_string + "%N")
      end
      message_already_read [ a_user_id ] := true
      Result := tcp_message [ a_user_id ]
    end

  send_to_tcp (a_message: STRING; a_user_id: INTEGER)
      --send message to user with specific user id.
    do
      if get_accepted_tcp_socket ( a_user_id ). is_writable then
         get_accepted_tcp_socket ( a_user_id ). putstring (a_message)
         get_accepted_tcp_socket ( a_user_id ). put_new_line
        debug ("connection")
          Print ("sent to user: " + a_user_id .out + "%N" + a_message + "%N")
        end
      else
        debug ("connection")
          Print ("sending failed: %N" + a_message + "%N")
        end
      end
    rescue
    end

  disconnect_user_tcp ( a_user_id : INTEGER)
      --open slot of a disconnected user for new connetion.
    do
      debug ("connection")
        print ("disconnect user: " + a_user_id .out + "%N")
      end
      accepted_sockets [ a_user_id ] := create {NETWORK_STREAM_SOCKET}.make
      user_connected_tcp [ a_user_id ] := false
    rescue
    end

  is_connection_broken ( a_user_id : INTEGER): BOOLEAN
      --is the user at a specific position still there?
    do
      Result := get_accepted_tcp_socket ( a_user_id .item). is_readable
    end

feature {NONE} -- Sockets
```

```
    get_accepted_tcp_socket (a_user_id : INTEGER): NETWORK_STREAM_SOCKET
            --get a socket of a connected user.
        require
            user_connected_tcp [ a_user_id ] = true
        do
            Result := accepted_sockets [ a_user_id ]
        end

    get_udp_socket : NETWORK_DATAGRAM_SOCKET
            --get the udp socket.
        local
            l_udp_socket : NETWORK_DATAGRAM_SOCKET
        once
            create l_udp_socket .make_bound (datagram_socket_port )
            l_udp_socket . enable_broadcast
            Result := l_udp_socket
        end

    get_tcp_socket : NETWORK_STREAM_SOCKET
            --get the tcp socket used to connect to new users.
        local
            l_tcp_socket : NETWORK_STREAM_SOCKET
        once
            create l_tcp_socket . make_server_by_port ( stream_socket_port )
            l_tcp_socket . listen (1)
            l_tcp_socket . set_non_blocking
            l_tcp_socket . set_out_of_band_inline
            Result := l_tcp_socket
        end

feature {NONE} -- Global Variables

    host_ip_address : STRING
            --the ip address where the server is located. It is used to connect to the stream
              socket.

    stream_socket_port : INTEGER
            --The port on which the stream socket gets connected.

    datagram_socket_port : INTEGER
            --The port on which the datagram socket sends and receives messages.

    user_connected_tcp : ARRAY[BOOLEAN]
            --is a user connected at a specific user id?

    accepted_sockets : ARRAY[NETWORK_STREAM_SOCKET]
            --all sockets to which users can connect.

    overflow_socket : NETWORK_STREAM_SOCKET
            --socket to signal user that there are too many connections open on the server.

    tcp_message: ARRAY[RS_DISTRIB_GUI_MESSAGE]
            --message buffer for tcp messages.
```

```
end
```

C.1.6 RS_DISTRIB_GUI_CONSOLE_LISTENER

```
note
  description :
    "A listener to handle console input."

class
  RS_DISTRIB_GUI_CONSOLE_LISTENER

inherit
  EXECUTION_ENVIRONMENT

create
  make

feature -- Access

  make (a_Buffer : separate RS_DISTRIB_GUI_BUFFER)
      --creation
    do
      buffer := a_buffer
      execution_stopped := false
    end

  run
      --listens to stop command in console.
    do
      io.put_new_line -- used to flush console to prevent the immediate termination of
          the program if the last console entry was stop
      from io.read_line
      until io.last_string.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.stop) or
          execution_stopped
      loop
        io.read_line
        sleep ({RS_DISTRIB_GUI_CONSTANTS}.wait_console_listener * 1_000_000)
      end
      stop_execution (buffer)
    rescue
    end

  stop
      --stop the execution of server, application and self
    do
      execution_stopped := true
      stop_execution (buffer)
    end

feature {NONE} -- Basic Features

  stop_execution (a_buffer : separate RS_DISTRIB_GUI_BUFFER)
      --sends stop comand to buffer to stop server and application
    do
```

```
        a_buffer .stop
    end

feature {NONE} -- Global Variables

   buffer : separate RS_DISTRIB_GUI_BUFFER
        --separate buffer

   execution_stopped : BOOLEAN
        --has execution been stopped from an other place than console
end
```

C.1.7 RS_DISTRIB_GUI_CONSTANTS

```
note
   description :
     "Constants"

class
   RS_DISTRIB_GUI_CONSTANTS

feature -- JSON Constants

   Error: STRING = "error"
        --used to signal an error in JSON.

   Parse_error : STRING = "parse_error"
        --used to signal a parsing-error in JSON.

   Request: STRING = "request"
        --used to signal a request for the udp socket in JSON.

   Register : STRING = "register"
        --used to signal a request to register a status in JSON.

   Unregister: STRING = "unregister"
        --used to signal a request to unregister a status in JSON.

   Help: STRING = "help"
        --used to signal a request to the help message in JSON.

   Ok: STRING = "ok"
        --used to signal no problems with message in JSON.

   Safe: STRING = "safe"
        --used to signal safe current state in JSON.

   Load: STRING = "load"
        --used to signal load state in JSON.

   get_user_id : STRING = "get_user_id"
        --used to request user id in JSON.

   Address: STRING = "address"
```

```
        --used to signal address request for udp socket in JSON.

   Port: STRING = "port"
        --used to signal port request for udp socket in JSON.

feature -- Command Constants

   None_allowed: STRING = "none"
        --used to signal no arguments allowed in command instruction.

    Integer_allowed : STRING = "integer"
        --used to signal integer arguments allowed in command instruction.

    String_allowed : STRING = "string"
        --used to signal string arguments allowed in command instruction.

   Double_allowed: STRING = "double"
        --used to signal double arguments allowed in command instruction.

   Custom_allowed: STRING = "custom"
        --used to signal custom string arguments allowed in command instruction.

   Range_allowed: STRING = "range"
        --used to signal range arguments allowed in command instruction.

feature -- Connection Constants

   Max_packet_size: INTEGER = 1024
        --maximal number of characters the udp socket can read.

   Max_number_of_connections: INTEGER = 10
        --maximal number of clients able to connect to the server. Setting this too big
            (>100) can result in poor performance.

feature -- Performance Constants

   Wait_Server: INTEGER = 0
        --How long does the Server wait betwen each loop executions in miliseconds.
            Setting this too high (>100) can result in poor performance.

   Wait_Application : INTEGER = 0
        --How long does the Application wait betwen each loop executions in miliseconds.

    Wait_Console_Listener : INTEGER = 500
        --How long does the Console_Listener wait betwen each loop executions in
            miliseconds.

feature -- Other Constants

   Stop: STRING = "stop"
        --string that terminates the execution if entered in the console

    default_size : INTEGER = 10
```

```
      --Size of all hashtables, queues and arrays when initialised. All grow when needed
          .

end
```

C.1.8 RS_DISTRIB_GUI_CONTROLLER

```
note

  description :
    "A Basis for a ROBOSCOOP application which wants to use the distributed GUI.
         This class handles communication and timing."

deferred class
   RS_DISTRIB_GUI_CONTROLLER

inherit
  EXECUTION_ENVIRONMENT

feature -- Access

  frozen make (a_buffer : separate RS_DISTRIB_GUI_BUFFER)
      --create.
    do
      buffer := a_buffer
      stopped := false
      time_interval := 200
      at_create
      create last_time .make_now
    end

  frozen run
      --initialize and run loop.
    do
      initialize
      run_loop
    end

feature {NONE} -- Basic Features

  frozen send_command_instruction (a_command_instruction:
       RS_DISTRIB_GUI_COMMAND_INSTRUCTION)
      --send a command instruction to the buffer/server to update or create.
    do
      sent_separate ( buffer , a_command_instruction. serialize )
    end

  frozen send_status ( a_status : RS_DISTRIB_GUI_STATUS)
      --send a status to the server/buffer to update or create.
    do
      sent_separate ( buffer , a_status . serialize )
    end

  frozen stop ( a_buffer : separate RS_DISTRIB_GUI_BUFFER)
```

```
      --stop application, server and console_listener.
    do
      a_buffer .stop
      stopped := true
    end

  frozen set_time_interval ( a_miliseconds : INTEGER)
      --set the lower bound of the interval between the executions of '
          execute_every_timeinterval'
    do
      time_interval := a_miliseconds
    end

  frozen get_time_interval : INTEGER
      --get the lower bound of the interval between the executions of '
          execute_every_timeinterval'
    do
      Result := time_interval
    end

feature {NONE} -- Deferred Features

  at_create
      --is executed at creation of the class before the server is running.
    deferred end

  initialize
      --is executed at the start of run when the server is already running.
    deferred end

  execute
      --is executed every loop iteration of run.
    deferred end

  handle_command (a_command: RS_DISTRIB_GUI_COMMAND)
      --is executed when a command is sent from the buffer/server.
    deferred end

  execute_every_time_interval
      --is executed at most every specified time interval, default is 200ms.
    deferred end

feature {NONE} -- Intern Methods

  frozen sent_separate ( a_buffer : separate RS_DISTRIB_GUI_BUFFER; message: STRING)
      --send to separate buffer.
    do
      a_buffer . set_server (message)
    end

  frozen run_loop
      --loop over methods until stop is called.
    local
      l_time , l_last_time_every , l_last_time_exe : TIME
    do
      from
          initialize
        create l_time .make_now
        create l_last_time_every .make_now
        create l_last_time_exe .make_now
      until
        stopped
      loop
        l_time .make_now
        l_time . fine_second_add (− time_interval / 1000)
        if l_time > l_last_time_every then
            execute_every_time_interval
            l_last_time_every .make_now
        end
        check_buffer ( buffer )
        l_time .make_now
        dt := l_time . fine_second − l_last_time_exe . fine_second
        if dt < 0 then
          dt := dt + 60
        end
        l_last_time_exe .make_now
        execute
        sleep ({RS_DISTRIB_GUI_CONSTANTS}.wait_application ∗ 1_000_000)
      end
    end


  frozen check_buffer ( a_buffer : separate RS_DISTRIB_GUI_BUFFER)
      −−check if buffer has elements and handle them.
    local
      l_command: STRING
    do
      if a_buffer . has_application_element then
        create l_command.make_from_separate ( a_buffer . get_application )
        handle_command (create {RS_DISTRIB_GUI_COMMAND}.make_from_serialisation (
              l_command))
      end
      if a_buffer . is_stopped then
        stop ( buffer )
      end
    end

feature {NONE} −− Global Variables

  frozen buffer : separate RS_DISTRIB_GUI_BUFFER
      −−separate buffer for communication between application and server.

  frozen stopped: BOOLEAN
      −−is server running?

  frozen time_interval : INTEGER
      −−amount of miliseconds between execution of ”execute_every_time_interval”
  frozen last_time : TIME
      --when was the ast time the ”execute_every_time_interval” was calculated?

  frozen dt: DOUBLE
      --How much time passed since the last execution of ”execute”

end
```

C.1.9 RS_DISTRIB_GUI_MAIN

```
note
   description :
     ”The main class. Server, Application and Console_Listener are created and started
          here.”

class
  RS_DISTRIB_GUI_MAIN [G −> RS_DISTRIB_GUI_CONTROLLER create make end]


create
  run

feature −− Access

  run ( a_host_ip_address : STRING; a_stream_socket_port : INTEGER; a_datagram_socket_port:
        INTEGER)
     −−create and run server, application and console_listener
     local
        l_buffer : separate RS_DISTRIB_GUI_BUFFER
        l_application : separate G
        l_address : separate STRING
     do
        l_address := a_host_ip_address
        create host_ip_address .make_from_separate ( l_address )
        create l_buffer .make
        create server .make ( l_buffer , host_ip_address , a_stream_socket_port ,
              a_datagram_socket_port )
        create console_listener .make ( l_buffer )
        create l_application .make ( l_buffer )
        application := l_application
        run_separate ( server , application , console_listener )
     end

feature {NONE} −− Basic Features

  run_separate ( a_server : separate RS_DISTRIB_GUI_SERVER; a_application: separate
        RS_DISTRIB_GUI_CONTROLLER; a_console_listener: separate
        RS_DISTRIB_GUI_CONSOLE_LISTENER)
      −−run seprate objects
     do
        a_server .run
        a_application .run
        a_console_listener .run
     end
```

```
feature {NONE} -- Global Variables

   server : separate RS_DISTRIB_GUI_SERVER
         --separate server

   application : separate RS_DISTRIB_GUI_CONTROLLER
         --separate application

    console_listener : separate RS_DISTRIB_GUI_CONSOLE_LISTENER
         --sepatrate console listener

   host_ip_address : separate STRING

end
```

C.1.10 RS_DISTRIB_GUI_MESSAGE

```
note
   description :
     "A JSON object with a light parser."

class
  RS_DISTRIB_GUI_MESSAGE

create
  make,make_from_packet , make_from_string

feature -- Access
  make ( a_user_id : INTEGER)
        --create.
     do
        create hash_table .make (10)
         hash_table .wipe_out
         user_id := a_user_id
     end

  make_from_string (a_raw_message: STRING; a_user_id: INTEGER)
        --create and parse string.
     do
        make(a_user_id )
        parse (a_raw_message)
     end

  make_from_packet (a_raw_message: PACKET; a_user_id: INTEGER)
        --create and parse packet.
     local
         l_string_builder : STRING
        i : INTEGER
     do
        from
           i := 0
            l_string_builder := ""
        until
        not a_raw_message. valid_position  (i)
      loop
         l_string_builder  .append (a_raw_message.at  (i).out)
        i  := i  + 1
      end
      make_from_string  ( l_string_builder  ,  a_user_id )
    end


  user_id : INTEGER
      --the user id from the creator of the message

  to_string :  STRING
      --string representation
    local
       l_string_builder  : STRING
       l_first  : BOOLEAN
    do
       l_string_builder   := ""
       l_first   := true
      across  hash_table . current_keys  as key loop
        if not l_first  then
           l_string_builder  .append (",")
        end
         l_first   := false
         l_string_builder  .append ( item_to_string  (key.item))
      end
      Result :=  l_string_builder
    end

  to_sending_string :  STRING
      --string representation
    local
       l_string_builder  : STRING
       l_first  : BOOLEAN
    do
       l_string_builder   := ""
       l_first   := true
      across  hash_table . current_keys  as key loop
        if not l_first  then
           l_string_builder  .append (",")
        end
         l_first   := false
         l_string_builder  .append ( item_to_sending_string  (key.item))
      end
      Result :=  l_string_builder
    end

  to_string_only  (a_argument: STRING): STRING
      --string representation of one JSON Identifier and value.
    do
      if  hash_table .has  (a_argument) then
        Result :=  item_to_string  (a_argument)
      else
```

```
                Result := ""
            end
        end

    is_empty: BOOLEAN
            --has the JSON set elements?
        do
            Result := hash_table.count = 0
        end

feature -- Basic Features

    remove (a_key: STRING)
            --remove identifier and value from JSON set.
        do
            hash_table.remove (a_key.as_lower)
        end

    put (a_key: STRING; a_item: STRING)
            --put identifier and value to JSON set.
        do
            if hash_table.has (a_key.as_lower) then
                hash_table.replace (a_item, a_key.as_lower)
            else
                hash_table.put (a_item, a_key.as_lower)
            end

        end

    add (a_key: STRING; a_item: STRING)
            --add value to an identifier in JSON set.
        do
            a_item.prune_all_leading ('{')
            a_item.prune_all_trailing ('}')
            if attached hash_table.at (a_key.as_lower) as l_old_value then
                if l_old_value.ends_with ("}") then
                    l_old_value.prune_all_trailing ('}')
                    hash_table.replace (l_old_value + "," + a_item + "}", a_key.as_lower)
                else
                    hash_table.replace ("{" + l_old_value + "," + a_item + "}", a_key.as_lower)
                end
            else
                hash_table.put (a_item, a_key.as_lower)
            end
        end

    get (a_key: STRING): STRING
            --returns value of identifier in JSON set
        do
            if attached hash_table.item (a_key.as_lower) as l_item then
                Result := l_item
            else
                Result := ""
            end
```

```
		end

	has (key: STRING): BOOLEAN
			--has the JSON set this identifier?
		do
			Result := hash_table.has (key.as_lower)
		end

	get_keys: ARRAY[STRING]
			--get all identifiers.
		do
			Result := hash_table.current_keys
		end

	consists_only_of (a_key: STRING; a_arguments: LINKED_LIST[STRING]): BOOLEAN
			--do the values at this identifier consist only of values passed in list?
		do
			if attached hash_table.at (a_key) as l_item then
				l_item.prune_all_leading ('{')
				l_item.prune_all_trailing ('}')
				Result := across l_item.split (',') as l_element all
					across a_arguments as l_argument some l_argument.item.as_lower.is_equal (
						l_element.item.as_lower) end
				end
			else
				Result := false
			end
		end

feature {NONE} -- Parsing

	parse (a_string: STRING)
			--parse a string to JSON, only subset of JSON is allowed.
		local
			i: INTEGER
		do
			from
				i := 0
			until
				i > a_string.count
			loop
				i := parse_item (a_string, i + 1)
			end
		end

	parse_item (a_string: STRING; a_position: INTEGER): INTEGER
			--parse an item.
		local
			l_key, l_position: INTEGER
			l_quote: CHARACTER
		do
			l_quote := '!'
			l_quote := l_quote.next
			a_string.prune_all (l_quote)
```

```
    from
      l_position := a_position
      l_key := 0
    until
      a_string.at (l_position).is_equal (’,’) or
      l_position > a_string.count
    loop
      if a_string.at (l_position).is_equal (’:’) then
        l_position := parse_value (a_string, l_position + 1)
        if l_position <= a_string.count and not a_string.at (l_position).is_equal (’,’)
            then
          add ({RS_DISTRIB_GUI_CONSTANTS}.parse_error, ”Commands have to be
                separated by ’,’”)
        end
      elseif a_string.at (l_position).is_equal (’{’) or a_string.at (l_position).is_equal
          (’}’) or a_string.at (l_position).is_equal (’:’) or a_string.at (l_position).
          is_equal (’}’) then
        add ({RS_DISTRIB_GUI_CONSTANTS}.parse_error, ”Unexpected Bracket”)
        l_key := l_position
        l_position := a_string.count + 1
      else
        l_key := l_position
        l_position := l_position + 1
      end
    end
    if l_key = 0 then
      add ({RS_DISTRIB_GUI_CONSTANTS}.parse_error, ”Keys can not be empty”)
    end
    add (a_string.substring (a_position, l_key), a_string.substring (l_key + 2,
        l_position −1))
    Result := l_position
  end

parse_value (a_string: STRING; a_position: INTEGER): INTEGER
    −−parse an argument.
  local
    l_position : INTEGER
    l_in_brackets : BOOLEAN
  do
    from
      l_position := a_position
      if a_string.at (l_position).is_equal (’{’) then
        l_in_brackets := true
        l_position := l_position + 1
      else
        l_in_brackets := false
      end
    until
      (a_string.at (l_position).is_equal (’,’) and not l_in_brackets) or
      a_string.at (l_position).is_equal (’}’) or
      l_position > a_string.count
    loop
      if a_string.at (l_position).is_equal (’{’) and l_in_brackets then
```

```
          add ({RS_DISTRIB_GUI_CONSTANTS}.parse_error, "Nested Brackets are not
               allowed")
           l_position  := a_string .count + 1
        elseif a_string .at ( l_position ). is_equal  (':')  or a_string .at ( l_position ). is_equal
              ('}')  or a_string .at ( l_position ). is_equal  ('[')  or a_string .at ( l_position ).
             is_equal  (']')  then
          add ({RS_DISTRIB_GUI_CONSTANTS}.parse_error, "Unexpected charackter '" +
               a_string.at (l_position).out + "' ")
           l_position  := a_string .count + 1
        else
           l_position  := l_position  + 1
        end
      end
      if a_string .at ( l_position ). is_equal  ('}')  and not l_in_brackets  then
        add ({RS_DISTRIB_GUI_CONSTANTS}.parse_error, "Bracket was not opened")
         l_position  := a_string .count + 1
      end
      if l_position  <= a_string.count and not a_string . at ( l_position ). is_equal  (',')  then
         l_position  := l_position  + 1
      end
      Result := l_position
    end


feature {NONE} --Basic private Features

   item_to_string  (a_key: STRING): STRING
      --string representation of an element.
    do
      if attached hash_table .item (a_key) as l_item then
        if l_item . is_equal  ("") then
          Result := a_key
        else
          Result := a_key + ":" + l_item
        end
      else
        Result := ""
      end
    end

   item_to_sending_string  (a_key: STRING): STRING
      --JSON representation of an element.
    local
      l_quote: CHARACTER_8
    do
      create l_quote
      l_quote  := '!'
      l_quote  := l_quote .next
      if attached hash_table .item (a_key) as l_item then
        if l_item . is_equal  ("") then
          Result := l_quote .out + a_key + l_quote .out
        else
          Result := l_quote .out + a_key + l_quote .out + ":" + value_to_sending_string  (
               l_item .out)
      end
    else
      Result := ””
    end
  end

 value_to_sending_string  (a_value : STRING): STRING
    −−JSON representation of a value.
  local
    l_quote : CHARACTER_8
    i : INTEGER
  do
    l_quote  := ’%”’
    if  a_value.starts_with  (”{”) then
      from
        i  := 2
      until
        i  >= a_value.count
      loop
        if  a_value.at  (i).is_equal  (’,’)  or a_value.at  (i).is_equal  (’:’)  then
          if  a_value.at  (i  + 1).is_equal  (’{’)  then
            a_value.insert_character  (l_quote,  i+2)
          else
            a_value.insert_character  (l_quote,  i+1)
          end
          if  a_value.at  (i  − 1).is_equal  (’}’)  then
            a_value.insert_character  (l_quote,  i−1)
          else
            a_value.insert_character  (l_quote,  i)
          end
          i  := i  + 1
        end
        i  := i  + 1
      end
      a_value.insert_character  (l_quote,  2)
      a_value.insert_character  (l_quote,  a_value.count)
      Result := a_value
    else
      Result := l_quote.out + a_value + l_quote.out
    end
  end

get_key (a_message: STRING): STRING
    −−get the identifier of a parsed object.
  do
    Result := a_message.split  (’:’) .at  (1).as_lower
  end

get_value (a_message: STRING): STRING
    −−get the value of a parsed object.
  do
    if  a_message.split  (’:’) .count > 1 then
      Result := a_message.split  (’:’) .at  (2)
    else
```

```
        Result := ""
      end
    end

feature {NONE} --Global Variables

  hash_table: HASH_TABLE[STRING,STRING]
      --JSON set

end
```

C.1.11 RS_DISTRIB_GUI_MESSAGE_PROCESSOR

```
note
   description :
     "Messages get processed and verified here. This contains sending feedback or
          commands to application or sockets when needed."

class
  RS_DISTRIB_GUI_MESSAGE_PROCESSOR

create
  make

feature -- Access

  make (a_address : STRING; a_port: STRING; a_buffer: separate RS_DISTRIB_GUI_BUFFER)
      --create and initialize.
    do
      buffer := a_buffer
      initialize_udp_commands
        initialize_tcp_statuses
       initialize_tcp_commands
      address_value := a_address
      port_value := a_port
    end

  add_command_instruction (a_command_instruction:
       RS_DISTRIB_GUI_COMMAND_INSTRUCTION)
      --add command to useable commands.
    require
      no_meta_command: (not a_command_instruction.name.is_equal ({
           RS_DISTRIB_GUI_CONSTANTS}.unregister)) and
               (not a_command_instruction.name.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.
                    register)) and
               (not a_command_instruction.name.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.
                    load)) and
               (not a_command_instruction.name.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.
                    safe)) and
               (not a_command_instruction.name.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.
                    get_user_id))
    do
      if tcp_commands.has (a_command_instruction.name) then
        tcp_commands.replace(a_command_instruction, a_command_instruction.name)
      else
        tcp_commands.put(a_command_instruction, a_command_instruction.name)
      end

    end

  add_status (a_status: RS_DISTRIB_GUI_STATUS_INTERN)
      --add status to registerable statuses.
    local
      i: INTEGER
    do
      if attached tcp_statuses.at (a_status.name) as l_status then
        l_status.set_value (a_status.get_value)
      else
        tcp_statuses.put (a_status, a_status.name)
        from
          i := 1
        until
          i > {RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections
        loop
          unregistered_tcp_statuses.at (i).put ("", a_status.name)
          i := i + 1
        end
      end
    end

  execution_stopped: BOOLEAN
    do
      Result := execution_stopped_separte (buffer)
    end

  check_buffer
      --check separate buffer
    do
      check_buffer_separate (buffer)
    end

  listen_for_status_changes (a_user_id: INTEGER): RS_DISTRIB_GUI_MESSAGE
      --check if a registered status has changed since last iteration.
    local
      l_answer: RS_DISTRIB_GUI_MESSAGE
    do
      create l_answer.make (a_user_id)
      across tcp_statuses as l_status loop
        if l_status.item.changed and registered_tcp_statuses [a_user_id].has (l_status.item.
            name) then
          l_answer.add (l_status.item.name, l_status.item.get_value)
        end
      end
      Result := l_answer
    end

  reset_changed
      --sets all changed flags to false
    do
      across  tcp_statuses  as  l_status  loop
        l_status .item.set_unchanged
      end

    end

  process_tcp  (a_message: RS_DISTRIB_GUI_MESSAGE): RS_DISTRIB_GUI_MESSAGE
      --process parsed message from tcp socket
    do
      verify  (a_message, tcp_commands)
      if  not (a_message.has  ({RS_DISTRIB_GUI_CONSTANTS}.error) or
        a_message.has  ({RS_DISTRIB_GUI_CONSTANTS}.parse_error) or
        a_message.has  ({RS_DISTRIB_GUI_CONSTANTS}.help))
        then
        handle_message_tcp (a_message)
      end
      Result := answer_message_tcp(a_message)
    end

  process_udp  (a_message: RS_DISTRIB_GUI_MESSAGE): RS_DISTRIB_GUI_MESSAGE
      --process parsed mesage from udp socket.
    do
      verify  (a_message,udp_commands)
      Result := answer_message_udp (a_message)
    end

  clean_registered_commands  ( a_user_id :  INTEGER)
      --reset the state of  registered  commands for an user id.
    local
      i: INTEGER
    do
      from i := 1
      until   registered_tcp_statuses  [ a_user_id ]. current_keys .count  < i
      loop
         unregister_status   (   registered_tcp_statuses   [ a_user_id ]. current_keys . at( i ) ,   a_user_id
            )
        i  :=  i  + 1
      end
    end

feature {NONE} -- separate acess

   check_buffer_separate    ( a_buffer :  separate RS_DISTRIB_GUI_BUFFER)
      --check if buffer has a message and if yes process it.
    local
      l_message: STRING
    do
      if  a_buffer . has_server_element   then
        create  l_message . make_from_separate  ( a_buffer . get_server )
        if  l_message . starts_with   ("s") then
          add_status  (create  {RS_DISTRIB_GUI_STATUS_INTERN}.make_from_serialisation (
               l_message))
        elseif  l_message . starts_with   ("c") then
```

```
          add_command_instruction (create {RS_DISTRIB_GUI_COMMAND_INSTRUCTION}.
              make_from_serialisation (l_message))
        else
          debug ("message_processor")
            print ("ERROR wrong serialisation")
          end
        end
      end
    end

  execution_stopped_separte ( a_buffer : separate RS_DISTRIB_GUI_BUFFER): BOOLEAN
    do
      Result := a_buffer . is_stopped
    end

feature {NONE} -- Initialisation Features

  initialize_udp_commands
      --initialize request commands for udp.
    local
      l_argument_list : LINKED_LIST[STRING]
      l_request_command: RS_DISTRIB_GUI_COMMAND_INSTRUCTION
    do
      create udp_commands.make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
      create l_request_command.make ({RS_DISTRIB_GUI_CONSTANTS}.request)
      create l_argument_list .make
      l_argument_list .wipe_out
      l_argument_list .extend ({RS_DISTRIB_GUI_CONSTANTS}.address)
      l_argument_list .extend ({RS_DISTRIB_GUI_CONSTANTS}.port)
      l_request_command. allow_custom_strings ( l_argument_list )
      l_request_command. allow_multiple
      udp_commands.put (l_request_command, l_request_command.name)
    end

  initialize_tcp_commands
      --inilialize commands that are always useable.
  local
      l_command: RS_DISTRIB_GUI_COMMAND_INSTRUCTION
    do
      create tcp_commands.make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)

      create l_command.make ({RS_DISTRIB_GUI_CONSTANTS}.register)
      l_command.allow_multiple
      tcp_commands.put (l_command, l_command.name)

      create l_command.make ({RS_DISTRIB_GUI_CONSTANTS}.unregister)
      l_command.allow_multiple
      tcp_commands.put (l_command, l_command.name)

      create l_command.make ({RS_DISTRIB_GUI_CONSTANTS}.load)
      l_command.allow_multiple
      tcp_commands.put (l_command, l_command.name)

      create l_command.make ({RS_DISTRIB_GUI_CONSTANTS}.safe)
      l_command.allow_string
      tcp_commands.put (l_command, l_command.name)

      create l_command.make ({RS_DISTRIB_GUI_CONSTANTS}.safe)
      l_command.allow_string
      tcp_commands.put (l_command, l_command.name)

      create l_command.make ({RS_DISTRIB_GUI_CONSTANTS}.get_user_id)
      l_command.allow_none
      tcp_commands.put (l_command, l_command.name)

    end

  initialize_tcp_statuses
      --initialize empty registered statuses tables for each possible user.
    local
      i: INTEGER
    do
      create tcp_statuses .make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
      create registered_tcp_statuses . make_filled (create {HASH_TABLE[STRING, STRING
           ]}.make ({RS_DISTRIB_GUI_CONSTANTS}.default_size), 1, {
           RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections)
      create unregistered_tcp_statuses . make_filled (create {HASH_TABLE[STRING,
           STRING]}.make ({RS_DISTRIB_GUI_CONSTANTS}.default_size), 1, {
           RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections)
      create saved_statuses .make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
      from
        i := 1
      until
        i > {RS_DISTRIB_GUI_CONSTANTS}.max_number_of_connections
      loop
          registered_tcp_statuses .at (i) := create {HASH_TABLE[STRING, STRING]}.make
            ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
          unregistered_tcp_statuses .at (i) := create {HASH_TABLE[STRING, STRING]}.
            make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
        i := i + 1
      end
    end

feature {NONE} -- Communication Features

  answer_message_tcp (a_message: RS_DISTRIB_GUI_MESSAGE):
       RS_DISTRIB_GUI_MESSAGE
      --create the message that is sent back via tcp.
    local
      l_answer: RS_DISTRIB_GUI_MESSAGE
    do
      create l_answer.make (a_message. user_id )
      if a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.error).is_equal ("") and
          a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.parse_error).is_equal ("") and
          not a_message.has ({RS_DISTRIB_GUI_CONSTANTS}.help) then
        l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.ok, "")
      elseif not a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.parse_error).is_equal ("")
           then
      l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.parse_error, a_message.get ({
              RS_DISTRIB_GUI_CONSTANTS}.parse_error))
    elseif not a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.error).is_equal ("") then
      l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.error, a_message.get ({
              RS_DISTRIB_GUI_CONSTANTS}.error))
    end

    if a_message.has ({RS_DISTRIB_GUI_CONSTANTS}.get_user_id) and l_answer.has ({
          RS_DISTRIB_GUI_CONSTANTS}.ok) then
      l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.get_user_id, l_answer.user_id.out)
    end

    if a_message.has ({RS_DISTRIB_GUI_CONSTANTS}.help) then
      if attached tcp_commands.at (a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.help))
            as l_command then
        l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.help, "{" + one_command_to_string
              (l_command, l_answer.user_id)+ "}")
      else
        l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.help, help_to_string (tcp_commands,
              l_answer.user_id))
      end
    end
    Result := l_answer
  end

answer_message_udp (a_message: RS_DISTRIB_GUI_MESSAGE):
      RS_DISTRIB_GUI_MESSAGE
    --create the mesage that is sent back via udp.
  local
    l_answer: RS_DISTRIB_GUI_MESSAGE
  do
    create l_answer.make (a_message.user_id)
    if a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.request).has_substring ({
          RS_DISTRIB_GUI_CONSTANTS}.port) then
      l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.port, port_value)
    end

    if a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.request).has_substring ({
          RS_DISTRIB_GUI_CONSTANTS}.address) then
      l_answer.put ({RS_DISTRIB_GUI_CONSTANTS}.address, address_value)
    end
    Result := l_answer
  end

handle_message_tcp (a_message: RS_DISTRIB_GUI_MESSAGE)
    --send verified message to application or/and execute commands in message on
          server
  do
    if a_message.has ({RS_DISTRIB_GUI_CONSTANTS}.register) then
      across a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.register).split (',') as l_status
              loop
          register_status (l_status.item, a_message.user_id)
      end
      a_message.remove({RS_DISTRIB_GUI_CONSTANTS}.register)
      end
      if a_message.has ({RS_DISTRIB_GUI_CONSTANTS}.unregister) then
        across a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.unregister).split (',') as
            l_status loop
          unregister_status ( l_status .item , a_message. user_id )
        end
        a_message.remove ({RS_DISTRIB_GUI_CONSTANTS}.unregister)
      end
      if a_message.has ({RS_DISTRIB_GUI_CONSTANTS}.safe) then
        safe_state (a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.safe), a_message.user_id)
        a_message.remove ({RS_DISTRIB_GUI_CONSTANTS}.safe)
      end
      if a_message.has ({RS_DISTRIB_GUI_CONSTANTS}.load) then
        load_state (a_message.get ({RS_DISTRIB_GUI_CONSTANTS}.load), a_message.user_id
            )
        a_message.remove ({RS_DISTRIB_GUI_CONSTANTS}.load)
      end
      across a_message. get_keys as l_key loop
        if not l_key .item. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.get_user_id) then
          send_command (create {RS_DISTRIB_GUI_COMMAND}.make (l_key.item, a_message.
              get (l_key.item), a_message.user_id), buffer)
        end
      end

    end

feature {NONE} -- Command Features

  send_command (a_command: RS_DISTRIB_GUI_COMMAND; a_buffer: separate
       RS_DISTRIB_GUI_BUFFER)
      --send a command to the buffer/application.
    do
      a_buffer . set_application (a_command. serialize )
    end

   register_status (a_status_name: STRING; a_user_id: INTEGER)
      --register status for a specific user id. Changes to this command will be sent to
          the user.
    do
      if unregistered_tcp_statuses .at ( a_user_id ).has (a_status_name) then
        if attached tcp_statuses .at (a_status_name) as l_status then
          l_status .set_changed
        end
         unregistered_tcp_statuses .at ( a_user_id ).remove (a_status_name)
         registered_tcp_statuses .at ( a_user_id ).put ("", a_status_name)

      end
    end

   unregister_status (a_status_name: STRING; a_user_id: INTEGER)
      --unregister status for a specific user id.
    do
      if registered_tcp_statuses .at ( a_user_id ).has (a_status_name) then
         registered_tcp_statuses .at ( a_user_id ).remove (a_status_name)
        unregistered_tcp_statuses .at (a_user_id).put ("", a_status_name)
      end
    end

  safe_state ( a_identifier : STRING; a_user_id: INTEGER)
    local
      l_hash_table : HASH_TABLE[STRING,STRING]
    do
      create l_hash_table .make ({RS_DISTRIB_GUI_CONSTANTS}.default_size)
      across
        registered_tcp_statuses .at (a_user_id). current_keys as key
      loop
        l_hash_table .put ("", key.item)
      end
      saved_statuses .put ( l_hash_table , a_identifier )
    end

  load_state ( a_identifier : STRING; a_user_id: INTEGER)
    do
      debug ("message_processor")
        print ("try to load %N")
      end
      clean_registered_commands ( a_user_id )
      if attached saved_statuses .at ( a_identifier ) as l_saved_statuses then
        across
          l_saved_statuses . current_keys as key
        loop
          debug ("message_processor")
            print ("I register " + key.item.out +"%N")
          end
          register_status (key.item, a_user_id )
        end
      end
    end

feature {NONE} -- Verification Features

  verify (a_message: RS_DISTRIB_GUI_MESSAGE; a_commands: HASH_TABLE[
      RS_DISTRIB_GUI_COMMAND_INSTRUCTION,STRING])
      --verify if the message meets all requirements. Generate error messages if not.
    local
      l_items : STRING
    do
      across a_message. get_keys as l_key loop
        if l_key .item. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.help) or
          l_key .item. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.parse_error) or
          l_key .item. is_equal ({RS_DISTRIB_GUI_CONSTANTS}.safe) then
          --Do Nothing
        elseif attached a_commands.at (l_key .item) as l_command then
          l_items := a_message.get (l_key .item)
          l_items . prune_all_leading ('{')
          l_items . prune_all_trailing ('}')
          if not l_command.multiple_allowed and l_items . split (',') .count > 1 then
```

```
                    a_message.add ({RS_DISTRIB_GUI_CONSTANTS}.error, l_key.item + " does not
                            allow multiple arguments")
                 else
                    across  l_items . split   (',')  as  l_item  loop
                       verify_argument  (a_message,  l_command,  l_item .item)
                    end
                 end
              else
                 a_message.add ({RS_DISTRIB_GUI_CONSTANTS}.error, "Unknown Identifier(" +
                        l_key.item + ")")
              end
           end
        end

     verify_register_argument   (a_message:  RS_DISTRIB_GUI_MESSAGE; a_argument: STRING)
           --verify if register  argument exists.
        do
           if  not across   unregistered_tcp_statuses  .at  (a_message. user_id ). current_keys  as key
                 some key .item . is_equal   (a_argument) end then
              add_bad_argument (a_message,  a_argument,   hash_table_to_string  (
                    unregistered_tcp_statuses  .at  (a_message. user_id )))
           end
        end

     verify_unregister_argument   (a_message:  RS_DISTRIB_GUI_MESSAGE; a_argument: STRING)

           --verify if unregister argument exists.
        do
           if  not across   registered_tcp_statuses  .at  (a_message. user_id ). current_keys  as key
                 some key .item . is_equal   (a_argument) end then
              add_bad_argument (a_message,  a_argument,   hash_table_to_string  (
                    registered_tcp_statuses  .at  (a_message. user_id )))
           end
        end

     verify_load_argument   (a_message:  RS_DISTRIB_GUI_MESSAGE; a_argument: STRING)
           --verify if load argument exists.
        do
           if  not across  saved_statuses . current_keys  as  key  some key .item . is_equal   (a_argument)
                 end then
              add_bad_argument (a_message,  a_argument,   hash_table_to_string  ( saved_statuses ))
           end
        end

     verify_argument  (a_message:  RS_DISTRIB_GUI_MESSAGE; a_command:
           RS_DISTRIB_GUI_COMMAND_INSTRUCTION; a_argument: STRING)
           --verify if argument meets requirements.
        do
           if  a_command.name.is_equal({RS_DISTRIB_GUI_CONSTANTS}.register) then
               verify_register_argument   (a_message,  a_argument)
           elseif   a_command.name.is_equal({RS_DISTRIB_GUI_CONSTANTS}.unregister) then
               verify_unregister_argument   (a_message,  a_argument)
           elseif   a_command.name.is_equal({RS_DISTRIB_GUI_CONSTANTS}.load) then
               verify_load_argument   (a_message,  a_argument)
```

```
      elseif a_command.string_allowed or (a_command.integer_allowed and a_argument.
           is_integer ) then
      elseif a_command.range_allowed and a_argument.is_integer then
        if a_argument. to_integer >= a_command.lower and a_argument.to_integer <=
             a_command.upper then
        else
          a_message.add ({RS_DISTRIB_GUI_CONSTANTS}.error, "Argument not in range("
                + a_argument + ";" + a_command.to_string_arguments + ")")
        end
      elseif a_command.has_custom_string (a_argument) then
      elseif a_command.none_allowed then
        if not a_argument. is_equal ("") then
          a_message.add ({RS_DISTRIB_GUI_CONSTANTS}.error, "No argument is allowed"
                )
        end
      else
        add_bad_argument (a_message, a_argument, a_command.to_string_arguments)
      end
    end

  add_bad_argument (a_message: RS_DISTRIB_GUI_MESSAGE; a_received: STRING; a_expected:
       STRING)
      --adds a "bad_argument" error to the message.
    do
      a_message.add ({RS_DISTRIB_GUI_CONSTANTS}.error, "Bad Argument(argument
           received: " + a_received + "; argument expected: " + a_expected + ")")
    end

feature {NONE} -- Serialisation Features

   help_to_string (a_commands: HASH_TABLE[
       RS_DISTRIB_GUI_COMMAND_INSTRUCTION,STRING]; a_user_id: INTEGER):
       STRING
      --generate help message.
    local
       l_result_string : STRING
    do
       l_result_string := "{help:STRING"
      across a_commands as l_command loop
         l_result_string .append ("," + one_command_to_string(l_command.item, a_user_id ))
      end
      Result := l_result_string + "}"
    end

  one_command_to_string (a_command: RS_DISTRIB_GUI_COMMAND_INSTRUCTION;
       a_user_id: INTEGER): STRING
    do
      if a_command.name.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.register) then
        Result := {RS_DISTRIB_GUI_CONSTANTS}.register + ":" + hash_table_to_string (
             unregistered_tcp_statuses . at ( a_user_id ))
      elseif a_command.name.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.unregister) then
        Result := {RS_DISTRIB_GUI_CONSTANTS}.unregister + ":" + hash_table_to_string (
             registered_tcp_statuses . at ( a_user_id ))
      elseif a_command.name.is_equal ({RS_DISTRIB_GUI_CONSTANTS}.load) then
```

```
        Result := {RS_DISTRIB_GUI_CONSTANTS}.load + ":" + hash_table_to_string (
            saved_statuses)
      else
        Result := a_command.to_string
      end
    end

  hash_table_to_string  ( a_hash_table : HASH_TABLE[ANY,STRING]): STRING
      --string representation of a hashtable.
    local
      l_string : STRING
      key_set : ARRAY[STRING]
    do
      key_set  := a_hash_table . current_keys
      l_string  := ""
      if key_set .count = 0 then
        l_string  := "NONE"
      elseif key_set .count = 1 then
        l_string  := key_set .at (1) .out
      elseif key_set .count > 1 then
        l_string .append ("{")
        across key_set as key loop
          if key.item. is_equal  ("") then
            l_string .append (" ",")
          else
            l_string .append (key.item + ",")
          end
        end
        l_string . prune_all_trailing  (',')
        l_string .append ("}")
      end
      Result := l_string
    end

  array_to_string  (a_array : ARRAY[ANY]): STRING
      --string representation of an array.
    local
      l_string : STRING
    do
      l_string  := ""
      across a_array as item loop
        l_string .append (item.item.out + ",")
      end
      l_string . prune_all_trailing  (',')
      Result := l_string
    end

feature {NONE} -- Global Variables

  address_value : STRING
      --ip address received from ROBOSCOOP_CONNECTION for tcp socket.

  port_value : STRING
      --port number received from ROBOSCOOP_CONNECTION for tcp socket.
```

```
 tcp_commands: HASH_TABLE[RS_DISTRIB_GUI_COMMAND_INSTRUCTION,STRING]
      --table of all useable commands via tcp socket.

 udp_commands: HASH_TABLE[RS_DISTRIB_GUI_COMMAND_INSTRUCTION,STRING]
      --table of all useable commands via udp socket.

 tcp_statuses : HASH_TABLE[RS_DISTRIB_GUI_STATUS_INTERN,STRING]
      --table of all useable statuses via tcp socket.

 saved_statuses : HASH_TABLE[HASH_TABLE[STRING,STRING],STRING]
      --table of all safed status sets.

  registered_tcp_statuses : ARRAY[HASH_TABLE[STRING,STRING]]
      --table of all registered tcp statuses.

  unregistered_tcp_statuses : ARRAY[HASH_TABLE[STRING,STRING]]
      --table of all unregistered tcp statuses.

 buffer : separate RS_DISTRIB_GUI_BUFFER
      --separate buffer

end
```

C.1.12 RS_DISTRIB_GUI_SERVER

```
note
   description :
     "The Server Cnnects the Connection and the Message_Processor classes. It listens to
          sockets and sends the messages to the Message_Processor."

class
  RS_DISTRIB_GUI_SERVER

inherit
  EXECUTION_ENVIRONMENT

create
  make

feature -- Access

  make ( a_buffer : separate RS_DISTRIB_GUI_BUFFER; a_address: separate STRING;
       a_stream_socket_port: INTEGER; a_datagram_socket_port: INTEGER)
       --create.
    local
       l_address : STRING
    do
       l_address := create {STRING}.make_from_separate (a_address)
       create connection.make ( l_address , a_stream_socket_port , a_datagram_socket_port )
       create message_processor .make (connection . get_address , connection . get_port , a_buffer )
    end

  run
```

```
            --run server.
        do
            running := true
            debug ("server")
                print ("Server startet!%N")
            end
            from until not running loop
                    listen_to_udp
                    listen_to_connection_changes
                    listen_to_tcp
                    listen_to_buffer
                    sleep ({RS_DISTRIB_GUI_CONSTANTS}.wait_server * 1_000_000)
            end
            connection.cleanup
            debug ("server")
                print ("Server stopped%N")
            end
        rescue
            connection.cleanup
        end

    stop_server
            --stop the loop, the application will terminate
        do
            running := false
        end

feature {NONE} --Basic Features

    listen_to_udp
            --listen to udp socket and process possible messages.
        local
            l_message: RS_DISTRIB_GUI_MESSAGE
        do
            if connection.is_ready_to_read_udp then
                l_message := connection.read_from_udp
                l_message := message_processor.process_udp (l_message)
                connection.send_to_udp (l_message.to_sending_string )
            end
        end

    listen_to_connection_changes
            --listen for new tcp connections.
        do
            connection.accept_tcp_socket
        end

    listen_to_tcp
            --listen to tcp socket and process possible messages.
        local
            l_message: RS_DISTRIB_GUI_MESSAGE
        do
            across connection.get_user_ids as l_user_id loop
                if connection.is_ready_to_read_tcp (l_user_id.item) then
            l_message := connection . read_from_tcp ( l_user_id .item)
            l_message := message_processor . process_tcp (l_message)
            connection . send_to_tcp (l_message . to_sending_string , l_user_id .item)
          end
          if connection . is_connection_broken ( l_user_id .item) then
            message_processor . clean_registered_commands ( l_user_id .item)
            connection . disconnect_user_tcp ( l_user_id .item)
          end
        end
      end

    listen_to_buffer
        --listen to messages from the application on the buffer.
      local
        l_message : RS_DISTRIB_GUI_MESSAGE
      do
        message_processor . check_buffer
        across connection . get_user_ids as l_user_id loop
          l_message := message_processor . listen_for_status_changes ( l_user_id .item)
          if not l_message . is_empty then
            connection . send_to_tcp (l_message . to_string , l_message . user_id )
          end
        end
        message_processor . reset_changed ;
        if message_processor . execution_stopped then
          stop_server
        end
      end

feature {NONE} -- Global Variables

  connection : RS_DISTRIB_GUI_CONNECTION
        --connection

  message_processor : RS_DISTRIB_GUI_MESSAGE_PROCESSOR
        --message_processor

  running: BOOLEAN
        --is the server running?
end
```

C.1.13 RS_DISTRIB_GUI_STATUS

```
note
  description :
    "A status which is used to send Updates from Application to Server."

class
  RS_DISTRIB_GUI_STATUS

create
  make

feature -- Access
```

```
  make (a_name: STRING; a_value: STRING)
      --create.
    do
      name := a_name
      value := a_value
    ensure
       no_forbidden_characters_in_name : not name.has (’,’) and not name.has (’:’)
       no_forbidden_characters_in_value : not value.has (’,’) and not value.has (’:’)
    end

  name: STRING
      --name of status.

  value: STRING
      --value of status.

  serialize : STRING
      --serialize object to make a separate into a non separate.
    do
      Result := ”s:” + name + ”:” + value
    end

  set_value (a_value: STRING)
    do
      value := a_value
    ensure
       no_forbidden_characters_in_value : not a_value.has (’,’) and not a_value.has (’:’)
    end
end
```

C.1.14 RS_DISTRIB_GUI_STATUS_INTERN

```
note
  description :
    ”A status which is used to know when to send updates from the server to the GUIs.”

class
  RS_DISTRIB_GUI_STATUS_INTERN

create
  make_from_name_and_value, make_from_serialisation

feature -- Access

  make_from_name_and_value (a_name: STRING; a_value: STRING)
      --create.
    do
      name := a_name
      value := a_value
      changed := true
    end

  make_from_serialisation (a_string : STRING)
```

```
			--create from serialisation, used to handle separate objects.
		require
			a_string.starts_with ("s")
		do
			name := a_string.split (':').at (2)
			value := a_string.split (':').at (3)
			changed := true
		end

	name: STRING
			--name of status.

	changed: BOOLEAN
			--has status changed?

feature -- Basic Features

	set_value (a_value: STRING)
			--set a value, if not equal to old one set changed to true.
		do
			if not value.is_equal (a_value) then
				value := a_value
				changed := true
			end
		end

	get_value: STRING
			--get value and set chaged to false.
		do
			Result := value
		end

	serialize: STRING
			--serialize object to make a separate into a non separate.
		do
			Result := "s:" + name + ":" + value + ":" + changed.out
		end

	set_unchanged
			-- sets fvalue of changed flag to false
		do
			changed := false
		end

	set_changed
			-- sets fvalue of changed flag to true
		do
			changed := true
		end

feature {NONE} -- Global Variables

	value: STRING
			--value of status.
```

```
end
```

C.2 RS_DISTRIB_GUI_JAVA_GUI

C.2.1 CONNECTION

```
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;
import java.io.PrintWriter;
import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.InetAddress;
import java.net.Socket;
import java.net.SocketException;

import org.eclipse.swt.widgets.Display;


public class Connection {

  Graphics graphics;
  Socket socket;
  DatagramSocket datagramSocket;
  Boolean connected;
  Display display;
  Boolean running;
  Long broadcastInterval = 5000l;
  Integer rep = 0;
  String address;
  Integer port;

  public Connection(Graphics graphics, Display display) {
    this.graphics = graphics;
    this.display = display;
    running = false;
    graphics.setStatus(0);
    try {
      datagramSocket = new DatagramSocket();
      datagramSocket.setBroadcast(true);
      datagramSocket.setSoTimeout(1);
    } catch (SocketException e) {
      graphics.sendToConsole("ERROR: Failed to initialize Socket.");
    }
  }

  public void run() {
    running = true;
    connected = false;
    graphics.setStatus(1);
    Thread thread = new Thread() {
      @Override
    public void run () {
      while (running) {
        display .syncExec (new Runnable () {
          @Override
          public void run () {
            if (! connected && running) {
              cleanSocket () ;
              sendBroadcast () ;
              listenForBroadcast () ;
            } else if (connected && running){
              listenForMessage () ;
            }
          }
        });
      }
      cleanSocket () ;
    }
  };
  thread . start () ;
}
public void stop () {
  running = false;
  connected = false;
  graphics . setStatus (0) ;
  graphics .sendToConsole("INFO: Server stopped.");
}

public void cleanSocket () {
  if ( socket != null)
    try {
      socket . close () ;
    } catch (IOException e) {
      graphics .sendToConsole("ERROR: Could not close Socket.S");
    }
}

Long lastTimeSent = 0l ;

private void sendBroadcast () {
  try {
    if (lastTimeSent + broadcastInterval < System.currentTimeMillis () ) {
      byte [] sendData = "\"request\":{\"address\",\"port\"}".getBytes () ;
      DatagramPacket sendPacket = new DatagramPacket(sendData, sendData.length,
          InetAddress .getByName("255.255.255.255"),8888);
      datagramSocket.send(sendPacket) ;
      graphics .sendToConsole("INFO: Broadcasts sent Nr." + rep);
      lastTimeSent = System.currentTimeMillis () ;
      rep++;
    }
  } catch (IOException e) {
    graphics .sendToConsole("ERROR: Failed to send Broadcast.");
  }
}
```

```
private void listenForBroadcast () {
  try {
      DatagramPacket receivePacket = new DatagramPacket(new byte[75], 75);
      try {
        datagramSocket.receive(receivePacket);
        byte[] recData = receivePacket.getData();
        String result = new String(recData);
        result = result.substring(0, result.lastIndexOf(”,eof”));
        System.out.println(result);
        int i = 0;
        String stringbuilder = ””;
        while (i < result.length()) {
          if (result.charAt(i) != ’”’)
            stringbuilder += result.charAt(i);
          i++;
        }
        result = stringbuilder;
        graphics.sendToConsole(”UDP:” + result + ”−−−−”);
        for (String element: result.split(”,”)) {
          if (element.startsWith(”port”))
            port = Integer.parseInt(element.split(”:”)[1]);
          else if (element.startsWith(”address”))
            address = element.split(”:”)[1];
        }
        try {
          socket = new Socket(address,port);
          connected = true;
          graphics.setStatus(2);
          sendMessage(”register:{x,y,speed,angular_speed,angular_rotation}”);
        } catch (IOException e)
        {
          e.printStackTrace();
          graphics.sendToConsole(”ERROR: Failed to generate socket”);

        }
      } catch (IOException e) {

      }
  } catch (Exception e) {
    e.printStackTrace();
  }
}

private void listenForMessage() {
  try {
    if (socket.getInputStream().available() > 0) {
      BufferedReader in = new BufferedReader( new InputStreamReader(socket.
          getInputStream()));
      String inputLine;
      inputLine = in.readLine();
      parseMessages(inputLine);
    }

  } catch (IOException e1) {
      graphics.sendToConsole(”ERROR: Failed to generate input writer.”);

    }
  }

  public void sendMessage (String message) {
      try {
        if (connected) {
          PrintWriter out = new PrintWriter(socket.getOutputStream(),true);
          out.print(message);
          out.println();
        }
      } catch (IOException e) {
        graphics.sendToConsole(”ERROR: Failed to generate output writer.”);
      } catch (Exception e) {
        graphics.sendToConsole(”ERROR: Failed to write, is server connected?”);

      }

  }

  public void parseMessages (String message) {
    int i = 0;
    int begin = 0;
    int inBrackets = 0;
    while (i < message.length()) {
      if (message.charAt(i) == ’{’)
        inBrackets ++;
      else if (message.charAt(i) == ’}’)
        inBrackets −−;
      else if (message.charAt(i) == ’,’ && inBrackets == 0) {
        parseMessage(message.substring(begin,i));
        begin = i + 1;
      }
      i++;
    }
    parseMessage(message.substring(begin,i));
  }

  public void parseMessage (String message) {
    String stringbuilder = ””;
    int i = 0;
    while (i < message.length()) {
      if (message.charAt(i) != ’\”’)
        stringbuilder += message.charAt(i);
      i++;
    }
    executeMessage (stringbuilder);
  }

  public void executeMessage (String message) {
    if (message.startsWith(”x:”))
      graphics.setX(Integer.parseInt(message.substring(2)));
    else if (message.startsWith(”y:”))
```

```
      graphics.setY(Integer.parseInt(message.substring(2)));
    else if (message.startsWith("speed:"))
      graphics.setSpeed(Integer.parseInt(message.substring(6)));
    else if (message.startsWith("angular_speed:"))
      graphics.setAngularSpeed(Integer.parseInt(message.substring(14)));
    else if (message.startsWith("angular_rotation:"))
      graphics.setAngularRotation(Double.parseDouble(message.substring(17)));
    else if (message.startsWith("ok"));
    else
      graphics.sendToConsole("unknown:" + message);

  }
}
```

C.2.2 Graphics

```
import java.util.LinkedList;

import org.eclipse.swt.SWT;
import org.eclipse.swt.events.KeyAdapter;
import org.eclipse.swt.events.KeyEvent;
import org.eclipse.swt.events.MouseAdapter;
import org.eclipse.swt.events.MouseEvent;
import org.eclipse.swt.events.SelectionAdapter;
import org.eclipse.swt.events.SelectionEvent;
import org.eclipse.swt.graphics.Point;
import org.eclipse.swt.layout.FormAttachment;
import org.eclipse.swt.layout.FormData;
import org.eclipse.swt.layout.FormLayout;
import org.eclipse.swt.widgets.Button;
import org.eclipse.swt.widgets.Composite;
import org.eclipse.swt.widgets.Display;
import org.eclipse.swt.widgets.Label;
import org.eclipse.swt.widgets.Scale;
import org.eclipse.swt.widgets.Shell;
import org.eclipse.swt.widgets.Text;
import org.eclipse.ui.forms.widgets.FormToolkit;
import org.eclipse.wb.swt.SWTResourceManager;

public class Graphics {

  protected Shell shell;
  private Text debugConsole;
  private Text inputTextField;
  private Scale scaleRotationSpeed;
  private final FormToolkit formToolkit = new FormToolkit(Display.getDefault());
  private Connection connection;
  private Scale scaleSpeed;
  private Composite rotation;
  private Composite robot;
  private Composite map;

  /**
   * Launch the application.
```

```
 * @param args
 * @wbp.parser.entryPoint
 */
public static void main(String[] args) {
  try {
    Graphics window = new Graphics();
    window.open();
  } catch (Exception e) {
    e.printStackTrace();
  }
}

/**
 * Open the window.
 */
public void open() {
  final Display display = Display.getDefault();
  createContents();
  shell.open();
  shell.layout();
  connection = new Connection(this, display);
  while (!shell.isDisposed()) {
    if (!display.readAndDispatch()) {
      display.sleep();
    }
  }
}

/**
 * Create contents of the window.
 * @wbp.parser.entryPoint
 */
protected void createContents() {
  shell = new Shell();
  shell.setMinimumSize(new Point(600, 900));
  shell.setSize(450, 300);
  shell.setText("SWT Application");
  shell.setLayout(new FormLayout());

  debugConsole = new Text(shell, SWT.BORDER | SWT.READ_ONLY | SWT.MULTI);
  FormData fd_debugConsole = new FormData();
  fd_debugConsole.bottom = new FormAttachment(100, -10);
  fd_debugConsole.right = new FormAttachment(0, 588);
  fd_debugConsole.left = new FormAttachment(0, 10);
  debugConsole.setLayoutData(fd_debugConsole);
  debugConsole.setEnabled(false);
  debugConsole.setBackground(SWTResourceManager.getColor(SWT.
      COLOR_INFO_FOREGROUND));

  scaleSpeed = new Scale(shell, SWT.NONE);
  FormData fd_scaleSpeed = new FormData();
  fd_scaleSpeed.right = new FormAttachment(100, -421);
  fd_scaleSpeed.left = new FormAttachment(0, 36);
  scaleSpeed.setLayoutData(fd_scaleSpeed);
scaleSpeed.setEnabled(false);

inputTextField = new Text(shell, SWT.BORDER);
inputTextField.addKeyListener(new KeyAdapter() {
  @Override
  public void keyPressed(KeyEvent e) {
    if (e.character == 13) {
      connection.sendMessage(inputTextField.getText());
    }
  }
});
FormData fd_inputTextField = new FormData();
fd_inputTextField.right = new FormAttachment(0, 549);
fd_inputTextField.top = new FormAttachment(0, 516);
fd_inputTextField.left = new FormAttachment(0, 48);
inputTextField.setLayoutData(fd_inputTextField);

scaleRotationSpeed = new Scale(shell, SWT.NONE);
scaleRotationSpeed.addMouseListener(new MouseAdapter() {
  @Override
  public void mouseUp(MouseEvent e) {
    connection.sendMessage("set_angular_speed:" + scaleRotationSpeed.getSelection());
  }
});
FormData fd_scaleRotationSpeed = new FormData();
fd_scaleRotationSpeed.bottom = new FormAttachment(100, -192);
fd_scaleRotationSpeed.left = new FormAttachment(0, 36);
scaleRotationSpeed.setLayoutData(fd_scaleRotationSpeed);

Label lblSpeed = new Label(shell, SWT.NONE);
FormData fd_lblSpeed = new FormData();
fd_lblSpeed.bottom = new FormAttachment(scaleSpeed, -6);
fd_lblSpeed.left = new FormAttachment(0, 92);
fd_lblSpeed.right = new FormAttachment(0, 141);
lblSpeed.setLayoutData(fd_lblSpeed);
lblSpeed.setText("Speed");

Label lblRotationspeed = new Label(shell, SWT.NONE);
fd_scaleRotationSpeed.top = new FormAttachment(lblRotationspeed, 1);
fd_scaleSpeed.bottom = new FormAttachment(lblRotationspeed, -26);
FormData fd_lblRotationspeed = new FormData();
fd_lblRotationspeed.left = new FormAttachment(0, 60);
fd_lblRotationspeed.bottom = new FormAttachment(100, -220);
lblRotationspeed.setLayoutData(fd_lblRotationspeed);
lblRotationspeed.setText("Rotation Speed");

map = formToolkit.createComposite(shell, SWT.NO_REDRAW_RESIZE);
map.setBackground(SWTResourceManager.getColor(SWT.COLOR_WHITE));
FormData fd_map = new FormData();
fd_map.bottom = new FormAttachment(0, 510);
fd_map.right = new FormAttachment(0, 549);
fd_map.top = new FormAttachment(0, 10);
fd_map.left = new FormAttachment(0, 49);
map.setLayoutData(fd_map);
```

```
formToolkit . paintBordersFor (map);

robot = formToolkit . createComposite (map, SWT.NONE);
robot .setBackground(SWTResourceManager.getColor(SWT.COLOR_RED));
robot .setBounds(243, 243, 20, 20);
formToolkit . paintBordersFor ( robot );
robot . setLayout ( null );

rotation = formToolkit . createComposite ( robot , SWT.NONE);
rotation .setBackground(SWTResourceManager.getColor(SWT.COLOR_BLACK));
rotation .setBounds(0, 0, 5, 5);
formToolkit . paintBordersFor ( rotation );
rotation . setLayout ( null );

fd_scaleRotationSpeed . right = new FormAttachment(100, −421);

Button btnAccelerate = new Button( shell , SWT.NONE);
btnAccelerate .addMouseListener(new MouseAdapter() {
  @Override
  public void mouseDown(MouseEvent e) {
    connection .sendMessage(”start_accelerate”);
  }
  @Override
  public void mouseUp(MouseEvent e) {
    connection .sendMessage(”stop_changing_speed”);

  }
});


FormData fd_btnAccelerate = new FormData();
fd_btnAccelerate . left = new FormAttachment(0, 303);
fd_btnAccelerate . right = new FormAttachment(100, −95);
fd_btnAccelerate . top = new FormAttachment(inputTextField, 6);
btnAccelerate .setLayoutData( fd_btnAccelerate );
btnAccelerate . addSelectionListener (new SelectionAdapter () {
  @Override
  public void widgetSelected ( SelectionEvent e) {
  }
});
btnAccelerate . setText (”Accelerate”);

Button btnBrake = new Button( shell , SWT.NONE);
btnBrake.addMouseListener(new MouseAdapter() {
  @Override
  public void mouseDown(MouseEvent e) {
    connection .sendMessage(”start_brake”);
  }
  @Override
  public void mouseUp(MouseEvent e) {
    connection .sendMessage(”stop_changing_speed”);

  }
});
```

```
FormData fd_btnBrake = new FormData();
fd_btnBrake.right = new FormAttachment(btnAccelerate, 0, SWT.RIGHT);
fd_btnBrake.left = new FormAttachment(0, 303);
btnBrake.setLayoutData(fd_btnBrake);
btnBrake.addSelectionListener(new SelectionAdapter() {
  @Override
  public void widgetSelected(SelectionEvent e) {
  }
});
btnBrake.setText(”Brake”);


Button btnLeft = new Button(shell, SWT.NONE);
fd_btnBrake.bottom = new FormAttachment(btnLeft, 56, SWT.BOTTOM);
fd_btnBrake.top = new FormAttachment(btnLeft, 6);
fd_btnAccelerate.bottom = new FormAttachment(btnLeft, −6);
fd_lblRotationspeed.right = new FormAttachment(btnLeft, −44);
FormData fd_btnLeft = new FormData();
fd_btnLeft.bottom = new FormAttachment(lblRotationspeed, 0, SWT.BOTTOM);
fd_btnLeft.left = new FormAttachment(0, 245);
fd_btnLeft.top = new FormAttachment(0, 605);
btnLeft.setLayoutData(fd_btnLeft);
btnLeft.addMouseListener(new MouseAdapter() {
  @Override
  public void mouseDown(MouseEvent e) {
    connection.sendMessage(”start_turn_left”);
  }
  @Override
  public void mouseUp(MouseEvent e) {
    connection.sendMessage(”stop_turn”);
  }
});
btnLeft.setText(”Left”);

Button btnStop = new Button(shell, SWT.NONE);
btnStop.addMouseListener(new MouseAdapter() {
  @Override
  public void mouseDown(MouseEvent e) {
    connection.sendMessage(”stop”);
  }
});
fd_btnLeft.right = new FormAttachment(btnStop, −6);
FormData fd_btnStop = new FormData();
fd_btnStop.left = new FormAttachment(0, 351);
fd_btnStop.top = new FormAttachment(btnAccelerate, 6);
fd_btnStop.bottom = new FormAttachment(lblRotationspeed, 0, SWT.BOTTOM);
btnStop.setLayoutData(fd_btnStop);
btnStop.setText(”Stop”);

Button btnRight = new Button(shell, SWT.NONE);
btnRight.addMouseListener(new MouseAdapter() {
  @Override
  public void mouseDown(MouseEvent e) {
    connection .sendMessage(”start_turn_right”) ;
  }
  @Override
  public void mouseUp(MouseEvent e) {
    connection .sendMessage(”stop_turn”);
  }
});
fd_btnStop . right = new FormAttachment(btnRight, −6);
FormData fd_btnRight = new FormData();
fd_btnRight .bottom = new FormAttachment(debugConsole, −72);
fd_btnRight . top = new FormAttachment(btnAccelerate, 6) ;
fd_btnRight . right = new FormAttachment(inputTextField, 0, SWT.RIGHT);
fd_btnRight . left = new FormAttachment(0, 457);
btnRight .setLayoutData(fd_btnRight ) ;
btnRight. addSelectionListener (new SelectionAdapter () {
  @Override
  public void widgetSelected ( SelectionEvent e) {
  }
});
btnRight. setText (”Right”);

connectionInfo = new Text( shell , SWT.BORDER);
fd_debugConsole.top = new FormAttachment(0, 727);
connectionInfo . setEnabled (false) ;
connectionInfo . setEditable (false) ;
connectionInfo .setBackground(SWTResourceManager.getColor(SWT.COLOR_GREEN));
FormData fd_connectionInfo = new FormData();
fd_connectionInfo . right = new FormAttachment(scaleRotationSpeed, 35, SWT.RIGHT);
fd_connectionInfo . left = new FormAttachment(scaleRotationSpeed, −75);
fd_connectionInfo .top = new FormAttachment(0, 689);
connectionInfo .setLayoutData( fd_connectionInfo ) ;
formToolkit .adapt( connectionInfo , true, true);

Button btnRunServer = new Button(shell, SWT.NONE);
btnRunServer.addMouseListener(new MouseAdapter() {
  @Override
  public void mouseDown(MouseEvent e) {
    if (! connection .running)
      connection .run() ;
    else
      connection . stop () ;
  }
});
FormData fd_btnRunServer = new FormData();
fd_btnRunServer. right = new FormAttachment(connectionInfo, −6);
fd_btnRunServer.top = new FormAttachment(scaleRotationSpeed, 6) ;
btnRunServer.setLayoutData(fd_btnRunServer);
formToolkit .adapt(btnRunServer, true, true);
btnRunServer.setText (”connect”);
FormData fd_canvas = new FormData();
fd_canvas . top = new FormAttachment(lblSpeed, 0, SWT.TOP);
fd_canvas . right = new FormAttachment(btnAccelerate, −68);
FormData fd_canvas_1 = new FormData();
fd_canvas_1 .bottom = new FormAttachment(lblSpeed, 0, SWT.BOTTOM);
```

```
    fd_canvas_1.right = new FormAttachment(btnAccelerate, -60);
    fd_canvas_1.top = new FormAttachment(0, 549);
    fd_canvas_1.left = new FormAttachment(0, 208);
  }

  public void setX (Integer x) {
    x = (((x + map.getSize().x/2 + robot.getSize().x/2 + map.getSize().x) % map.getSize().x
         ) + map.getSize().x) % map.getSize().x ;
    robot.setBounds(x, robot.getLocation().y, robot.getSize().x, robot.getSize().y);
  }

  public void setY (Integer y) {
    y = (((y + map.getSize().y/2 + robot.getSize().y/2 + map.getSize().y) % map.getSize().y
         ) + map.getSize().y) % map.getSize().y ;
    robot.setBounds(robot.getLocation().x, y, robot.getSize().x, robot.getSize().y) ;
  }

  public void setStatus (int status) {
    if (status == 0)
      connectionInfo.setText("not running");
    else if (status == 1)
      connectionInfo.setText("connecting");
    else if (status == 2)
      connectionInfo.setText("connected");
    else
      connectionInfo.setText("unknown");
  }

  public void setSpeed (Integer speed) {
    scaleSpeed.setSelection(speed);
  }

  public void setAngularSpeed (Integer speed) {
    scaleRotationSpeed.setSelection(speed);
  }

  public void setAngularRotation (Double angle) {
    double x,y;
    int intx,inty;
    x = robot.getSize().x/2 + Math.sin(angle)*robot.getSize().x/2;
    y = robot.getSize().y/2 + Math.cos(angle)*robot.getSize().y/2;
    intx = Math.min((int) x, robot.getSize().x - rotation.getSize().x);
    inty = Math.min((int) y, robot.getSize().y - rotation.getSize().y);
    rotation.setLocation(intx,inty);
  }

  LinkedList<String> consoleContent;
  private Text connectionInfo;

  public void sendToConsole (String message) {
    if (message == null || !message.isEmpty() ) {
      if (message.length() > 100)
        message = message.substring(0, 100);
      if (consoleContent == null)
```

```
        consoleContent = new LinkedList<String>();
      if (consoleContent.size() > 7)
        consoleContent.remove();
      consoleContent.add(message);
      String finalstring = "";
      for (String line : consoleContent){
        finalstring += line + "\n";
      }
      finalstring = finalstring.substring(0, finalstring.length() -1);
      debugConsole.setText( finalstring );
      debugConsole.redraw();
    }
  }
}
```

C.3 RS_DISTRIB_GUI_SIMPLE_GUI

C.3.1 APPLICATION

```
note
  description : "Root class for this application."
  author      : "Generated by the New Vision2 Application Wizard."

class
  APPLICATION

inherit
  EV_APPLICATION

create
  make_and_launch

feature {NONE} -- Initialization

  make_and_launch
      -- Initialize and launch application
    do
      default_create
      prepare
      launch
    end

  prepare
      -- Prepare the first window to be displayed.
      -- Perform one call to first window in order to
      -- avoid to violate the invariant of class EV_APPLICATION.
    do
        -- create and initialize the first window.
      create first_window

      if attached first_window as window then
        -- Show the first window.
        --| TODO: Remove this line if you don't want the first
        --|        window to be shown at the start of the program.
        window.show
      end
      -- add idle action to check the buffer whenever the application is idle.
      add_idle_action (agent check_buffer )
    end


feature {NONE} -- Communication

  check_buffer

    do
      if attached first_window as window then
        window.check_buffer
      end
    end

feature {NONE} -- Implementation

  first_window: detachable MAIN_WINDOW
      -- Main window. Made detachable.

end -- class APPLICATION
```

C.3.2 BUFFER

```
note
  description: "The buffer used by the MAIN_WINDOW and the CONNECTION to
      communicate."

class
  BUFFER

create
  make

feature
  make
    do
      create incoming_values.make (10)
      create outgoing_values.make (10)
    end

  set_incoming (a_value: separate STRING)
    do
      incoming_values.extend (create {STRING}.make_from_separate (a_value))
    end

  get_incoming: STRING
    do
      if incoming_values.count > 0 then
        Result := incoming_values.item
        incoming_values.remove
      else
         Result := ""
      end
   end

  set_outgoing (a_value: separate STRING)
   do
      outgoing_values.extend (create {STRING}.make_from_separate (a_value))
   end

  get_outgoing: STRING
   do
      if outgoing_values.count > 0 then
         Result := outgoing_values.item
         outgoing_values.remove
      else
         Result := ""
      end
   end

  incoming_values: ARRAYED_QUEUE[STRING]
  outgoing_values: ARRAYED_QUEUE[STRING]
end
```

C.3.3 CONNECTION

```
note
   description: "The class is responsible for the communication with the server"

class
  CONNECTION

INHERIT
  EXECUTION_ENVIRONMENT

create
  make

feature

  make (a_buffer: separate BUFFER)
   do
      buffer := a_buffer
      create tcp_socket.make_client_by_port (2000,"84.75.135.127")
      tcp_socket.connect

      tcp_socket.put_string ("register:running")
      tcp_socket.put_new_line
   end

  run
   do
      from until false loop
         receive (buffer)
```

```
            send ( buffer )
        end
    end

    receive ( a_buffer : separate BUFFER)
        do
            if tcp_socket . is_readable then
                tcp_socket . read_line
                a_buffer . set_incoming ( tcp_socket . last_string )
            end
        end

    send ( a_buffer : separate BUFFER)
        local
            l_string : STRING
        do
            if not tcp_socket . is_connected then
                tcp_socket . connect
            end
            create l_string . make_from_separate ( a_buffer . get_outgoing )
            if l_string . count > 0 then
                tcp_socket . put_string ( l_string )
                tcp_socket . put_new_line
            end
        end

    close
        do
            tcp_socket . close
        end

    tcp_socket : NETWORK_STREAM_SOCKET

    buffer : separate BUFFER
end
```

C.3.4 INTERFACE_NAMES

```
note
    description : "Strings for the Graphical User Interface"
    author      : "Generated by the New Vision2 Application Wizard."

class
    INTERFACE_NAMES

feature -- Access

    Button_ok_item : STRING = "OK"
            -- String for "OK" buttons.

    Menu_file_item : STRING = "&File"
            -- String for menu "File"

    Menu_file_new_item : STRING = "&New%TCtrl+N"
```

```
      -- String for menu "File/New"

  Menu_file_open_item : STRING = "&Open...%TCtrl+O"
      -- String for menu "File/Open"

  Menu_file_save_item : STRING = "&Save%TCtrl+S"
      -- String for menu "File/Save"

  Menu_file_saveas_item : STRING = "Save &As..."
      -- String for menu "File/Save As"

  Menu_file_close_item : STRING = "&Close"
      -- String for menu "File/Close"

  Menu_file_exit_item : STRING = "E&xit"
      -- String for menu "File/Exit"

  Menu_help_item: STRING = "&Help"
      -- String for menu "Help"

  Menu_help_contents_item: STRING = "&Contents and Index"
      -- String for menu "Help/Contents and Index"

  Menu_help_about_item: STRING = "&About..."
      -- String for menu "Help/About"

  Label_confirm_close_window : STRING = "You are about to close this window.%NClick
       OK to proceed."
      -- String for the confirmation dialog box that appears
      -- when the user try to close the first window.

end -- class INTERFACE_NAMES
```

C.3.5 MAIN_WINDOW

```
note
  description : "Main window for this application"
  author: "Generated by the New Vision2 Application Wizard."

class
  MAIN_WINDOW

inherit
  EV_TITLED_WINDOW
    redefine
        create_interface_objects ,
        initialize ,
        is_in_default_state
    end

  INTERFACE_NAMES
    export
      {NONE} all
    undefine
```

```
        default_create , copy
    end

create
    default_create

feature

    check_buffer
    do
        check_buffer_scoop ( buffer )
    end

    check_buffer_scoop ( a_buffer : separate BUFFER)
    local
        message: STRING
    do
        message := create {STRING}.make_from_separate (a_buffer.get_incoming)
        if message.is_equal (”running:yes”) then
            button.set_text (”running”)
        elseif message.is_equal (”running:no”) then
            button.set_text (”not running”)
        end
    end

feature {NONE} -- Initialization

    create_interface_objects
        -- <Precursor>
    do
            -- Create main container.
        create main_container
        create buffer.make
        create manager.make (buffer)

    end

  manager: separate CONNECTION
  buffer : separate BUFFER

  run_manager (a_manager: separate CONNECTION)
    do
        a_manager.run
    end

   initialize
        -- Build the interface for this window.
    do
        Precursor {EV_TITLED_WINDOW}
        run_manager (manager)
        build_main_container
        extend (main_container)

            -- Execute 'request_close_window' when the user clicks
			-- on the cross in the title bar.
			close_request_actions.extend (agent request_close_window)

			-- Set the title of the window.
			set_title (Window_title)

			-- Set the initial size of the window.
			set_size (Window_width, Window_height)
		end

	is_in_default_state : BOOLEAN
			-- Is the window in its default state?
			-- (as stated in ' initialize ')
		do
			Result := (width = Window_width) and then
				(height = Window_height) and then
				( title . is_equal (Window_title))
		end


feature {NONE} -- Implementation, Close event

	request_close_window
			-- Process user request to close the window.
		local
			question_dialog : EV_CONFIRMATION_DIALOG
		do
			create question_dialog .make_with_text (Label_confirm_close_window)
			question_dialog .show_modal_to_window (Current)

			if question_dialog . selected_button ~ (create {EV_DIALOG_CONSTANTS}).ev_ok then
					-- Destroy the window.
				destroy
				if attached (create {EV_ENVIRONMENT}).application as a then
					close_connection_scoop (manager)
					scoop_destroy (a)
				end
			end
		end

	scoop_destroy ( a_application : separate EV_APPLICATION)
		do
			a_application . destroy
		end

	close_connection_scoop (a_manager: separate CONNECTION)
		do
			a_manager. close
		end

feature

	close_connection
		do
```

```
         close_connection_scoop   (manager)
      end

feature {NONE} -- Implementation

   main_container: EV_VERTICAL_BOX
         -- Main container (contains all widgets displayed in this window).

   build_main_container
         -- Populate 'main_container'.
      do
         create button
         button. set_text   ("not running")
         button. select_actions .extend (agent  clicked )
         main_container .extend (button)

      ensure
         main_container_created :  main_container  /= Void
      end

   button: EV_BUTTON


   clicked

      do
         if button . text . is_equal  ("not running") then
            send ("start", buffer )
         elseif  button . text . is_equal  ("running") then
            send ("stop", buffer )
         end
      end

   send (a_message: separate STRING; a_buffer: separate BUFFER)

      do
         a_buffer . set_outgoing  (a_message)
      end

feature {NONE} -- Implementation / Constants

   Window_title: STRING = ""
         -- Title of the window.

   Window_width: INTEGER = 550
         -- Initial width for this window.

   Window_height: INTEGER = 750
         -- Initial height for this window.

end
```

C.4 RS_DISTRIB_GUI_SIMULATOR

```
note
  description :
    ”A simple simulator of a Robot.”

class
  RS_DISTRIB_GUI_SIMULATOR

inherit RS_DISTRIB_GUI_APPLICATION

create
  make

feature {NONE} -- Basic Methods

  at_create
      --there is nothing to do at creation of the class .
    do

    end

   initialize
      --initialize statuses and commands.
    do
       initialize_statuses
      initialize_command_instructions
      set_time_interval  (100)
    end

   initialize_statuses
      --initialize default statuses .
    local
      l_status : RS_DISTRIB_GUI_STATUS
    do
      create l_status .make (”x”, ”0”)
      x := 0
      send_status ( l_status )

      create l_status .make (”y”, ”0”)
      y := 0
      send_status ( l_status )

      create l_status .make(”speed”, ”0”)
      speed := 0
      send_status ( l_status )

      create l_status .make (”angular_speed”, ”50”)
      angular_speed := 50
      send_status ( l_status )

      create l_status .make (”angular_rotation”, ”0”)
       angular_rotation := 0
      send_status ( l_status )
    end
```

```
 initialize_command_instructions
      --initialize command instructions.
   local
      l_command_instruction: RS_DISTRIB_GUI_COMMAND_INSTRUCTION
   do
      create l_command_instruction.make (”stop”)
      l_command_instruction.allow_none
      send_command_instruction (l_command_instruction)

      create l_command_instruction.make (” start_accelerate ”)
      l_command_instruction.allow_none
      send_command_instruction (l_command_instruction)

      create l_command_instruction.make (”stop_changing_speed”)
      l_command_instruction.allow_none
      send_command_instruction (l_command_instruction)

      create l_command_instruction.make (”start_brake”)
      l_command_instruction.allow_none
      send_command_instruction (l_command_instruction)

      create l_command_instruction.make (” start_turn_left ”)
      l_command_instruction.allow_none
      send_command_instruction (l_command_instruction)

      create l_command_instruction.make (”stop_turn”)
      l_command_instruction.allow_none
      send_command_instruction (l_command_instruction)

      create l_command_instruction.make (”start_turn_right”)
      l_command_instruction.allow_none
      send_command_instruction (l_command_instruction)

      create l_command_instruction.make (”set_angular_speed”)
      l_command_instruction.allow_range (0, 100)
      send_command_instruction (l_command_instruction)
   end

execute
      --calculations of new position and speed each loop iteration
   do
      angular_rotation := angular_rotation + angular_speed * dt * rotating / 50
      if angular_rotation > {SINGLE_MATH}.pi*2 then
         angular_rotation := angular_rotation - {SINGLE_MATH}.pi*2
      end
      x := x + {SINGLE_MATH}.sine (angular_rotation.truncated_to_real) * dt * speed
      y := y + {SINGLE_MATH}.cosine (angular_rotation.truncated_to_real) * dt * speed

      speed := speed + accelerating * dt * 10
      if speed < 0 then speed := 0
      elseif speed > 100 then speed := 100 end
   end

handle_command (a_command: RS_DISTRIB_GUI_COMMAND)
```

```
        --process a command received from the server.
    do
        print ("command handled%N")
        command_error := false
        if a_command.name.is_equal ("stop") then
            speed := 0
            accelerating := 0
            rotating := 0
        elseif a_command.name.is_equal (" start_accelerate ") then
            accelerating := 1
        elseif a_command.name.is_equal ("stop_changing_speed") then
            accelerating := 0
        elseif a_command.name.is_equal ("start_brake") then
            accelerating := -1
        elseif a_command.name.is_equal (" start_turn_left ") then
            rotating := 1
        elseif a_command.name.is_equal ("stop_turn") then
            rotating := 0
        elseif a_command.name.is_equal (" start_turn_right ") then
            rotating := -1
        elseif a_command.name.is_equal ("set_angular_speed") then
            angular_speed := a_command.argument.to_integer
        else
            command_error := true
        end
    ensure then
        command_error = false
    end

   execute_every_time_interval
        --send statuses every specified milisecond to not overflow the network. Default is
            200 milisec.
    local
            l_status : RS_DISTRIB_GUI_STATUS
        do
            create l_status .make ("x", x.rounded.out)
            send_status ( l_status )

            create l_status .make ("y", y.rounded.out)
            send_status ( l_status )

            create l_status .make ("speed", speed.rounded.out)
            send_status ( l_status )

            create l_status .make ("angular_speed", angular_speed.out)
            send_status ( l_status )

            create l_status .make ("angular_rotation",    angular_rotation .out)
            send_status ( l_status )
        end

feature {NONE} -- Global Variables

  x: DOUBLE
```

```
        --x coordinate of robot.

  y: DOUBLE
        --y coordinate of robot.

  angular_rotation : DOUBLE
        --radial orientation

  speed: DOUBLE
        --speed of robot.

  angular_speed: INTEGER
        --angular speed of robot.

  rotating : INTEGER
        --is robot rotating ? 1 for left , -1 for right and 0 for not.

  accelerating : INTEGER
        --is robot accelerating ? 1 for accelerating, -1 for braking and 0 for not.

  command_error: BOOLEAN
        --is the command received from the server not recognizable.
end
```

C.5 RS_DISTRIB_GUI_SIMPLE_SIMULATOR

```
note
  description :
    "A very simple simulator of a Robot which can only start and stop"

class
  RS_DISTRIB_GUI_SIMPLE_SIMULATOR

inherit
  RS_DISTRIB_GUI_CONTROLLER

create
  make

feature {NONE}

  at_create
        --initialize the global variable, no server needed.
    do
      create running.make ("running", "no")
    end

  initialize
    local
        --initialize status and command instruction at the server
      command_instruction: RS_DISTRIB_GUI_COMMAND_INSTRUCTION
    do
      send_status (running)
      create command_instruction.make ("start")
      command_instruction.allow_none
      send_command_instruction (command_instruction)

      create command_instruction.make ("stop")
      command_instruction.allow_none
      send_command_instruction (command_instruction)
    end

  execute
      --There is no need to calculate something in this very simple Simulator.
    do

    end

   execute_every_time_interval
      --Send the status to the server
    do
      send_status (running)
    end

  handle_command (a_command: RS_DISTRIB_GUI_COMMAND)
      --Handle received commands from the GUI.
    do
      if a_command.name.is_equal ("start") then
        running.set_value ("yes")
      elseif a_command.name.is_equal ("stop") then
        running.set_value ("no")
      end
    end

  running: RS_DISTRIB_GUI_STATUS
end
```

Bibliography

[1] Benjamin Morandi, Sebastian S. Bauer, and Bertrand Meyer. Scoop – a contract-based concurrent object-oriented programming model. In *Chapter in Advanced Lectures on Software Engineering*, 2010.

[2] Andrey Rusakov, Jiwon Shin, and Bertrand Meyer. Simple concurrency for robotics with the roboscoop framework. In *2014 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2014.

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