

# CaseStudy1

## Showing sonar distances on a radar

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## 1 Starting

Open an empty directory (e.g. `C:/iss2018Lab`) and

1. Clone the `iss2018Lab` repository by executing the following command:

```
git clone https://github.com/anatali/iss2018Lab.git
```

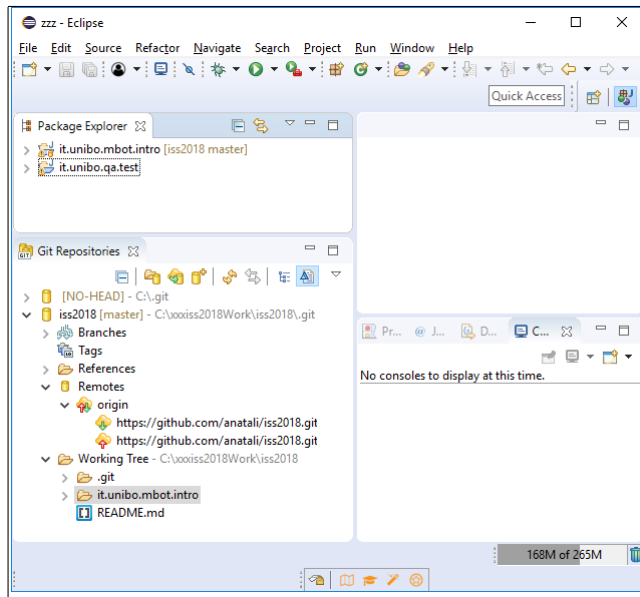
To update the repository, the command is `git pull`.

2. Now open the Eclipse working space into your working directory (e.g. `C:/iss2018Work`) and do:

Window -> ShowView -> Other -> Git -> Git Repositories

Add an existing local Git repository (C:/iss2018Lab)

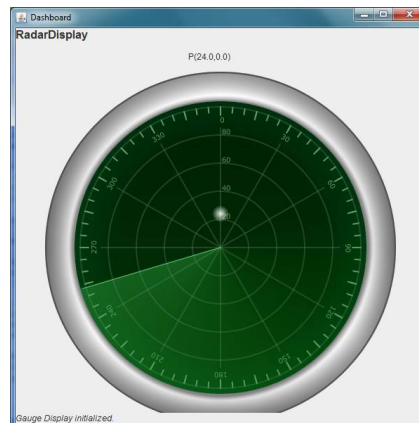
3. Import (by copying) into the current working space<sup>1</sup> the project `it.unibo.mbot.intro`. The result is:



4. In the project `it.unibo.mbot.intro`, the file `build/distributions/it.unibo.ctxRadarBase.MainCtxRadarBase-1.0.zip` includes the implementation of a software system able to display distance values on an output device that simulates the screen of a radar. To execute the application, *unzip* the file (into some other directory) and execute:

```
java -jar it.unibo.qactor.radar-1.0.jar
```

The virtual display shown by the radar system is:



<sup>1</sup> To avoid any conflict in project updating.

---

## 1.1 Interacting with the radar

In order to use the radar system, we must send messages to it, by using a TCP client connection on the port 8033. The messages must be *Strings* with the following structure:

```
1 msg(polarMsg,dispatch,SENDER,radarguibase,POLAR,MSGNUM)
```

where

- **SENDER** is the name (in lowercase) of the sender ;
- **POLAR** is a value of the form **p(D,ANGLE)**, with  $0 \leq D \leq 80$ ,  $0 \leq \text{ANGLE} \leq 180$ ;
- **MSGNUM** is a natural number

Let us implement a TCP client by using the **net** module of Node.js, that provides an asynchronous network wrapper. We start with the code that establishes a connection with the radar:

```
1 var net = require('net');
2 var host = "localhost";
3 var port = 8033;
4
5 console.log('connecting to ' + host + ":" + port);
6 var conn = net.connect({ port: port, host: host });
7 conn.setEncoding('utf8');
8
9 // when receive data back, print to console
10 conn.on('data',function(data) {
11     console.log(data);
12 });
13 // when server closed
14 conn.on('close',function() {
15     console.log('connection is closed');
16 });
17 conn.on('end',function() {
18     console.log('connection is ended');
19 });
```

**Listing 1.1.** TcpClientToRadar.js: set up a connection

Now, let us define some utility functions to send messages:

```
1 function sendMsg( msg ){
2     try{
3         console.log("SENDING " + msg );
4         conn.write(msg+"\n"); //Asynchronous!!!
5     }catch(e){
6         console.log("ERROR " + e );
7     }
8 }
9
10 function sendMsgAfterTime( msg, delay ){
11     setTimeout( function(){ sendMsg( msg ); }, delay);
12 }
```

**Listing 1.2.** TcpClientToRadar.js: utility

The **send** function writes the given data on the connection in asynchronous way; thus, it immediately returns control to the caller. The **sendMsgAfterTime** function allows us to delay the call after a given delay.

Finally, we send some data to the radar:

```
1 var msgNum=1;
2
3 sendMsgAfterTime("msg(polarMsg,dispatch,jsSource,radarguibase, p(50,30)," + msgNum++ +")", 1000);
4 sendMsgAfterTime("msg(polarMsg,dispatch,jsSource,radarguibase, p(50,90)," + msgNum++ +")", 2000);
5 sendMsgAfterTime("msg(polarMsg,dispatch,jsSource,radarguibase, p(50,150)," + msgNum++ +")", 3000);
6
7 setTimeout(function(){ conn.end(); }, 4000);
```

**Listing 1.3.** TcpClientToRadar.js: send data to radar

The radar shows the points, while the output of our client is:

```

1 connecting to localhost:8033
2 SENDING msg(polarMsg,dispatch,jsSource,radarguibase, p(50,30),1)
3 SENDING msg(polarMsg,dispatch,jsSource,radarguibase, p(50,90),2)
4 SENDING msg(polarMsg,dispatch,jsSource,radarguibase, p(50,150),3)
5 connection is ended
6 connection is closed

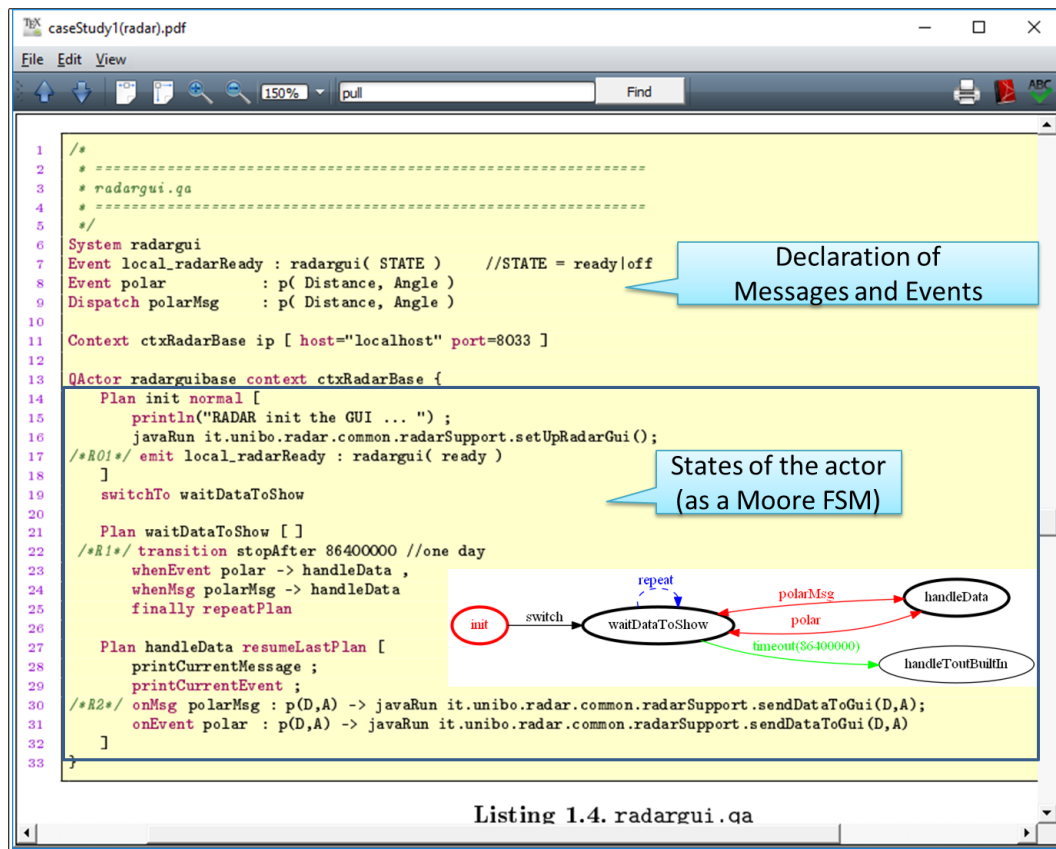
```

Instead of using Node, we could write a client for the radar in Java. This task is left to the reader.

## 1.2 Using the radar: a model-based approach

In the previous version of the radar client, we did not have any knowledge on the internal structure of the radar system. We exploited only the knowledge on the low-level structure of messages handled by the radar.

But, fortunately, there exist a high level description of the radar system, expressed in the high-level, custom modelling language *QActor*. This description is a (executable) model defined as follows:



The model describes the structure, the interaction and the behaviour of the radar. More specifically, it shows that the radar is able to handle messages and events *explicitly declared* at the very beginning of the model<sup>2</sup>:

```

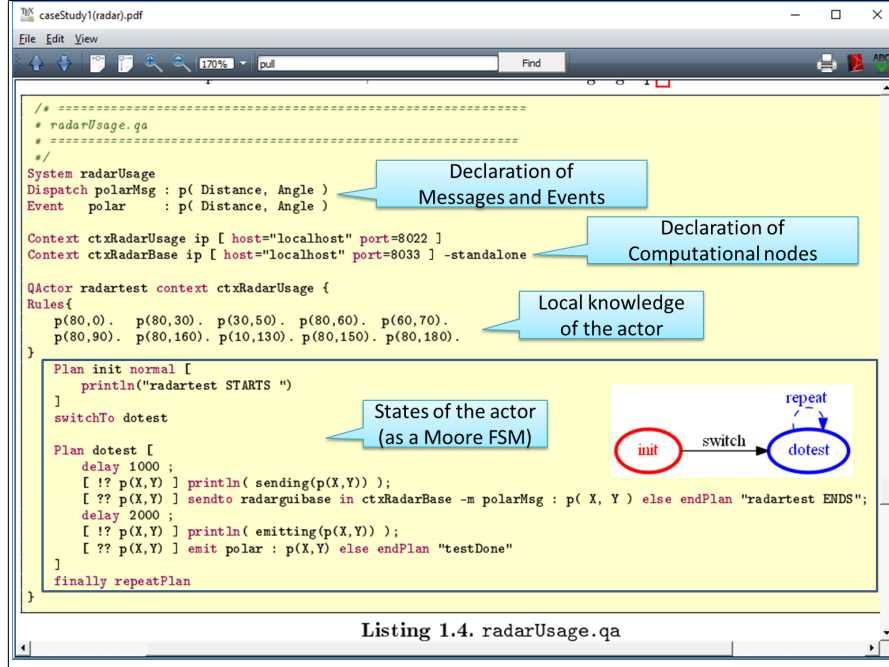
1 Dispatch polarMsg : p( Distance, Angle )
2 Event polar : p( Distance, Angle )

```

Since the message `polarMsg` is declared as a `Dispatch`, the interaction is of type 'fire-and-forget'.

<sup>2</sup> The event `local_radarReady` is a local event used internally.

Thus, another way to introduce a client of the radar system is to define the client by using the same modelling language used for the radar. Let us introduce an example of such a model<sup>3</sup>:



The model states that:

1. Our `radarUsage` system is a distributed system composed of two computational nodes (**Contexts**).
2. The node named `ctxRadarBase` is external to the systems (flag `-standalone`): it is the node that executes the given radar system. The context `ctxRadarUsage` represents the node in which we will run our radar client.
3. Our radar client is modelled as a `QActor` (`radartest`): it works as a finite state machine that (in the state `dotest`) sends messages and emits events. We will expand this point in in Subsection 1.2.1.
4. The messages and events involved in our system are *the same* defined in the radar model:

```

1 Dispatch polarMsg : p( Distance, Angle )
2 Event   polar    : p( Distance, Angle )
  
```

5. The data sent by our client are defined in the actor's knowledge base as a sequence of facts (in Prolog syntax) and are 'consumed' in the state `dotest`, by using **guards**.

From the model above, the `QActor` software factory generates an executable version written in Java. The main program is in the file:

```

1 it.unibo.mbot.intro/src-gen/it/unibo/ctxRadarUsage/MainCtxRadarUsage.java
  
```

If we run this file, the radar will show 10 points.

### 1.2.1 Sending messages and emitting events .

The concept of message in the `QActor` world implies that we must know the name of the message destination, that must be another `QActor`. This fact is reflected in the sentence:

```

1 sendto radarguibase in ctxRadarBase -m polarMsg : p( X, Y )
  
```

Note that the knowledge of the name of the receiving radar actor (`radarguibase`) is not required for events:

```

1 emit polar : p(X,Y)
  
```

<sup>3</sup> The code is in the file `it.unibo.mbot.intro/src/radarUsage.qa`.

---

## 2 The problem to solve

The problem now is the following:

with reference to a *mbot* physical robot working in virtual environment, build an application that sends to the radar the data sensed by the virtual and the real sonars. More specifically:

- the data of the *virtual sonar* **sonar1** must be displayed on the direction of angle=**30**;
- the data of the *virtual sonar* **sonar2** must be displayed on the direction of angle=**120**;
- the data of the *virtual sonar* on the virtual robot must be displayed on the direction of angle=**90** at the fixed distance of **40**;
- the data of the *real sonar* on the physical robot must be displayed on the direction of angle=**0**;

### 2.1 Requirements analysis

We ask the customer for the following basic information:

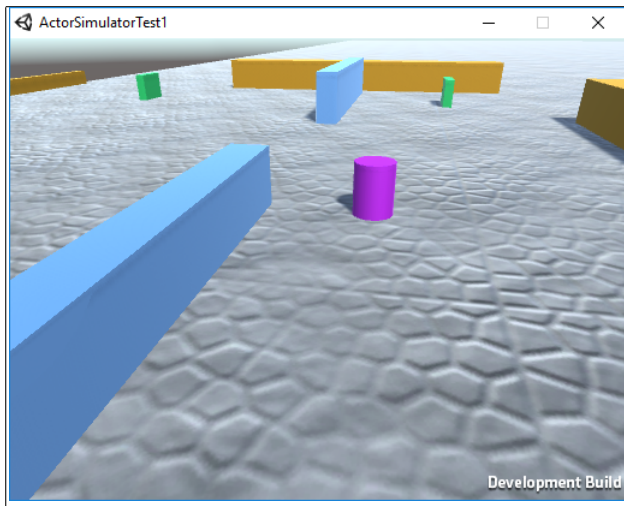
1. what is a *mbot*?
2. what is the virtual environment?
3. in which way we can obtain data from a virtual or from a real sonar?

#### 2.1.1 The virtual environment .

As regards the virtual environment, the answer is in the project [it.unibo.issMaterial](https://github.com/anatali/iss2018), available by cloning the *iss2018* GIT repository:

```
git clone https://github.com/anatali/iss2018.git
```

The virtual environment is an application written in Unity, included in the file: [it.unibo.issMaterial/Lab/virtualRobot.zip](https://github.com/anatali/iss2018). Let us *unzip* this file, and run **VirtualRobotE80.exe**. We obtain a scene showing an environment made of a set of walls and fixed obstacles, a mobile obstacle (the cylinder) and a sonar (the small boxes in green, named **sonar1** and **sonar2**):



The original Unity environment has been modified to interact with *QActor* systems. Details about this point are given in *IntroductionQa2017.pdf* (section 12)<sup>4</sup> (section 12).

The point to highlight here is that, when the virtual robot (**rover**) is intercepted by a sonar, the modified Unity system emits the *QActor* event **sonar : sonar(SONARNAME, TARGET, DISTANCE)** where **SONARNAME** is **sonar1** or

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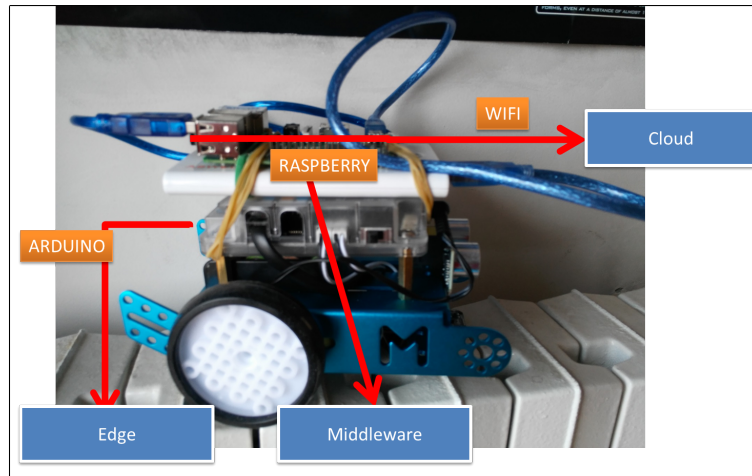
<sup>4</sup> The file is available in [it.unibo.issMaterial/issdocs/Material](https://github.com/anatali/iss2018).

`sonar2`. Moreover, the virtual `rover` is equipped (in its front) with a sonar, that emits the event `sonarDetect : sonarDetect(TARGET)` when detects an obstacle.

As regards the other questions, our goal is to build a model for the `mbot` and a model for the real sonar. The goal of these models is to clarify how we can exchange information with the corresponding entities of our `application domain`. The internal structure and the internal behaviour of the entities have relatively less importance at this stage.

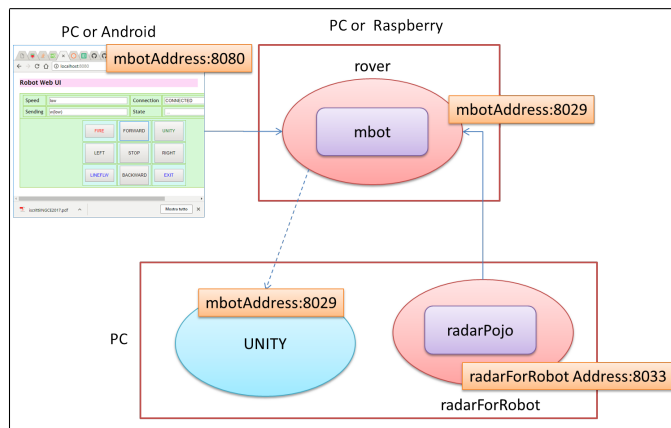
### 2.1.2 The mbot robot .

The `mbot` architecture is an example of a IoT architecture in which the `edge` part is implemented on Arduino, the `middleware` part is implemented on a RaspberryPi and the `cloud` part is implemented on a conventional PC.



Arduino handles physical devices such as motors and sensors, while RaspberryPi provides support for interaction with a remote node. More precisely, as regards the interactions:

- the robot communicates with external world via a `WIFI` local network. Let us denote as `mbotAddress` the IP of the robot in such a network;
- the robot accepts move commands sent via a browser connected to the address `mbotAddress:8080`;
- through the same web interface, the robot accepts a command to connect itself to a modified virtual Unity environment working on a remote PC in the local network;
- the robot emits *QActor* events (`sonar` and `sonarDetect`). This means that we can build a new *QActor* system including the robot and a *QActor* element able to perceive and handle these events.





```

1  /*
2  * =====
3  * radarForRobot.ga
4  * =====
5  */
6  System radargui
7  Event local_radarReady : radargui( STATE ) //STATE = ready|off
8  Event polar : p( Distance, Angle )
9
10 Context ctxRadarForRobot ip [ host="localhost" port=8033 ]
11 Context ctxMbotControl ip [ host="localhost" port=8029 ] -standalone
12
13 QActor radarrobot context ctxRadarForRobot {
14   Plan init normal [
15     javaRun it.unibo.radar.common.radarSupport.setUpRadarGui()
16   ]
17   switchTo waitDataToShow
18
19   Plan waitDataToShow [ ]
20   transition stopAfter 86400000 //on
21   whenEvent polar -> handleData
22   finally repeatPlan
23
24   Plan handleData resumeLastPlan [
25     printCurrentMessage ;
26     printCurrentEvent ;
27     onEvent polar : p(D,A) -> javaRun it.unibo.radar.common.radarSupport.sendDataToGui(D,A)
28   ]
29 }

```

Declaration of  
Messages and Events

```

stateDiagram-v2
    [*] --> waitDataToShow : switch
    waitDataToShow --> waitDataToShow : repeat
    waitDataToShow --> handleData : polar
    waitDataToShow --> handleToutBuiltIn : timeout(86400000)
    
```

### 2.1.3 The real sonar .