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:

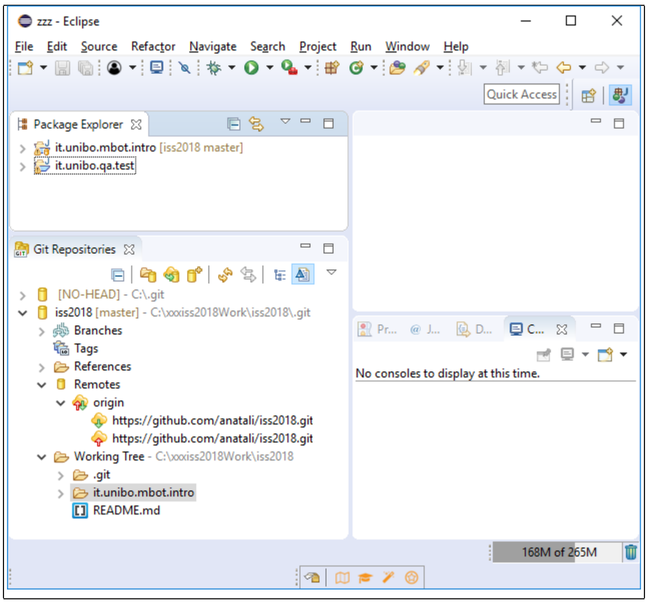
   ```
   git clone https://github.com/anatali/iss2018Lab.git
   ```

   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)
   ```

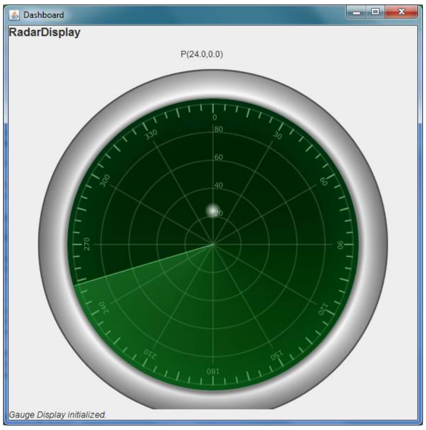
3. Import (by copying) into the current working space[1] the project it.unibo.mbot.intro. The result is:



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:



[1] 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:

```
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<=D<=80, 0<=ANGLE<=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 star with the code that establishes a connection with the radar:

```
var net = require('net');
var host = "localhost";
var port = 8033;

console.log('connecting to ' + host + ":" + port);
var conn = net.connect({ port: port, host: host });
conn.setEncoding('utf8');

// when receive data back, print to console
conn.on('data',function(data) {
    console.log(data);
});
// when server closed
conn.on('close',function() {
    console.log('connection is closed');
});
conn.on('end',function() {
    console.log('connection is ended');
});
```

Listing 1.1. TcpClientToRadar.js: set up a connection

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

```
function sendMsg( msg ){
    try{
        console.log("SENDING " + msg );
        conn.write(msg+"\n"); //Asynchronous!!!
    }catch(e){
        console.log("ERROR " + e );
    }
}

function sendMsgAfterTime( msg, delay ){
    setTimeout( function(){ sendMsg( msg ); }, delay);
}
```

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:

```
var msgNum=1;

sendMsgAfterTime("msg(polarMsg,dispatch,jsSource,radarguibase, p(50,30)," + msgNum++ +")", 1000);
sendMsgAfterTime("msg(polarMsg,dispatch,jsSource,radarguibase, p(50,90)," + msgNum++ +")", 2000);
sendMsgAfterTime("msg(polarMsg,dispatch,jsSource,radarguibase, p(50,150)," + msgNum++ +")", 3000);

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:

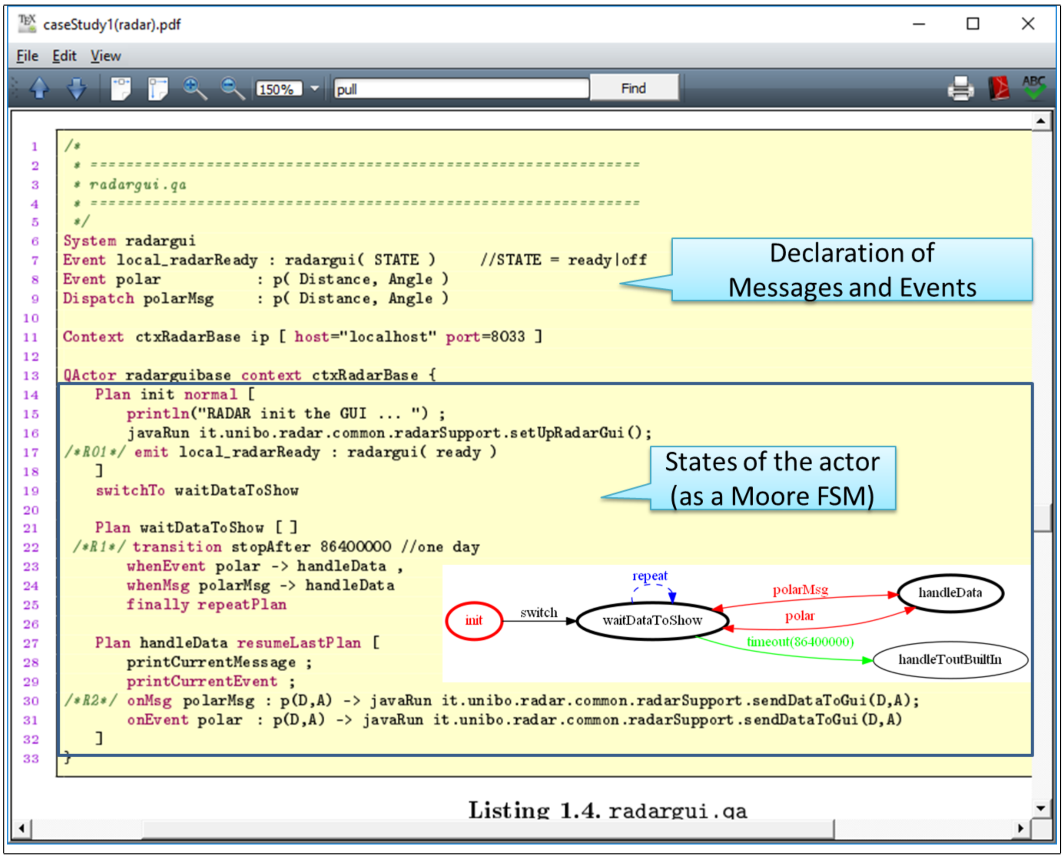
```
connecting to localhost:8033
SENDING msg(polarMsg,dispatch,jsSource,radarguibase, p(50,30),1)
SENDING msg(polarMsg,dispatch,jsSource,radarguibase, p(50,90),2)
SENDING msg(polarMsg,dispatch,jsSource,radarguibase, p(50,150),3)
connection is ended
connection is closed
```

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:



```
/*
 * ==============================================================
 * radargui.qa
 * ==============================================================
 */
System radargui
Event local_radarReady : radargui( STATE )     //STATE = ready|off
Event polar            : p( Distance, Angle )
Dispatch polarMsg      : p( Distance, Angle )

Context ctxRadarBase ip [ host="localhost" port=8033 ]

QActor radarguibase context ctxRadarBase {
    Plan init normal [
        println("RADAR init the GUI ... ") ;
        javaRun it.unibo.radar.common.radarSupport.setUpRadarGui();
/*R01*/ emit local_radarReady : radargui( ready )
    ]
    switchTo waitDataToShow

    Plan waitDataToShow [ ]
 /*R1*/ transition stopAfter 86400000 //one day
        whenEvent polar -> handleData ,
        whenMsg polarMsg -> handleData
        finally repeatPlan

    Plan handleData resumeLastPlan [
        printCurrentMessage ;
        printCurrentEvent ;
/*R2*/ onMsg polarMsg : p(D,A) -> javaRun it.unibo.radar.common.radarSupport.sendDataToGui(D,A);
        onEvent polar  : p(D,A) -> javaRun it.unibo.radar.common.radarSupport.sendDataToGui(D,A)
    ]
}
```


Listing 1.4. radargui.qa

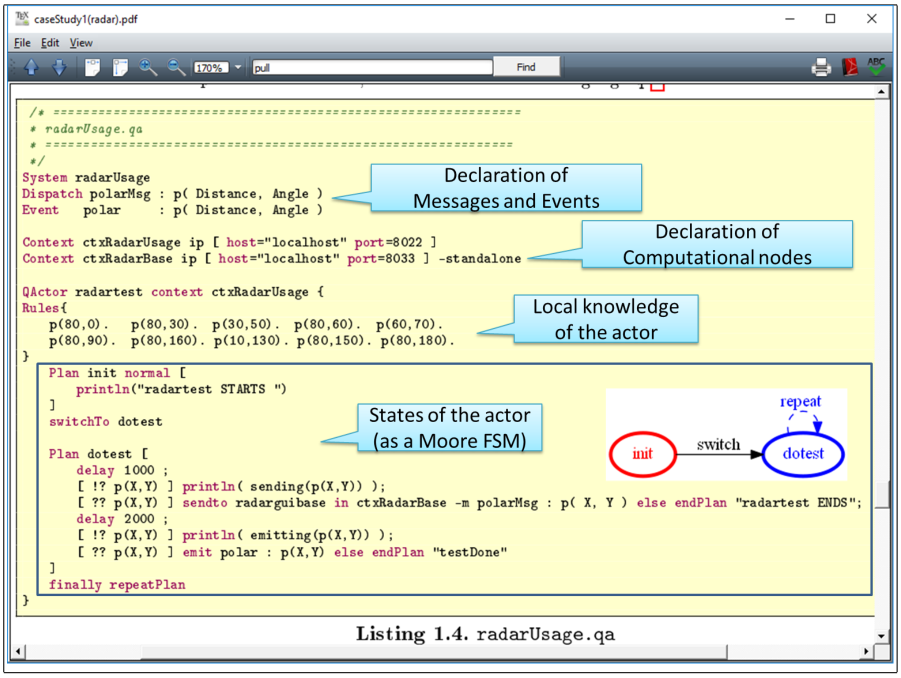
The model describes the structure, the interaction and the behaviour of the radar. More specifically, it shows that the radar is able to handle messages and events *explicitly declared* at the very beginning of the model[2]:

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

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

[2] 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[3]:



```
/* ================================================================
 * radarUsage.qa
 * ================================================================
 */
System radarUsage
Dispatch polarMsg : p( Distance, Angle )
Event    polar    : p( Distance, Angle )

Context ctxRadarUsage ip [ host="localhost" port=8022 ]
Context ctxRadarBase ip [ host="localhost" port=8033 ] -standalone

QActor radartest context ctxRadarUsage {
Rules{
   p(80,0).   p(80,30).  p(30,50).  p(80,60).  p(60,70).
   p(80,90).  p(80,160). p(10,130). p(80,150). p(80,180).
}
   Plan init normal [
      println("radartest STARTS ")
   ]
   switchTo dotest

   Plan dotest [
      delay 1000 ;
      [ !? p(X,Y) ] println( sending(p(X,Y)) );
      [ ?? p(X,Y) ] sendto radarguibase in ctxRadarBase -m polarMsg : p( X, Y ) else endPlan "radartest ENDS";
      delay 2000 ;
      [ !? p(X,Y) ] println( emitting(p(X,Y)) );
      [ ?? p(X,Y) ] emit polar : p(X,Y) else endPlan "testDone"
   ]
   finally repeatPlan
}
```


Listing 1.4. radarUsage.qa

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:

```
Dispatch polarMsg : p( Distance, Angle )
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:

```
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 known the name of the message destination, that must be another *QActor*. This fact is reflected in the sentence:

```
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:

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

[3] 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:

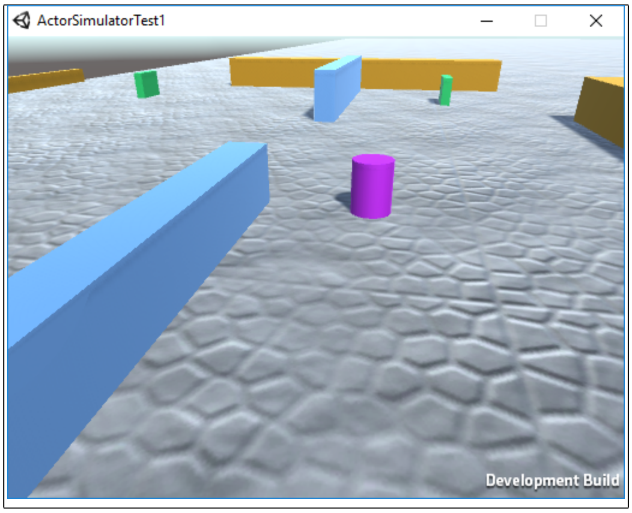
1. what is a `mbot`?
2. what is the virtual environment?
3. in which way we can obtain data from a virtual or from a real sonar?

2.1.1 The virtual environment .

As regards the virtual environment, the answer is in the project `it.unibo.issMaterial`, 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`. 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)[4] (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

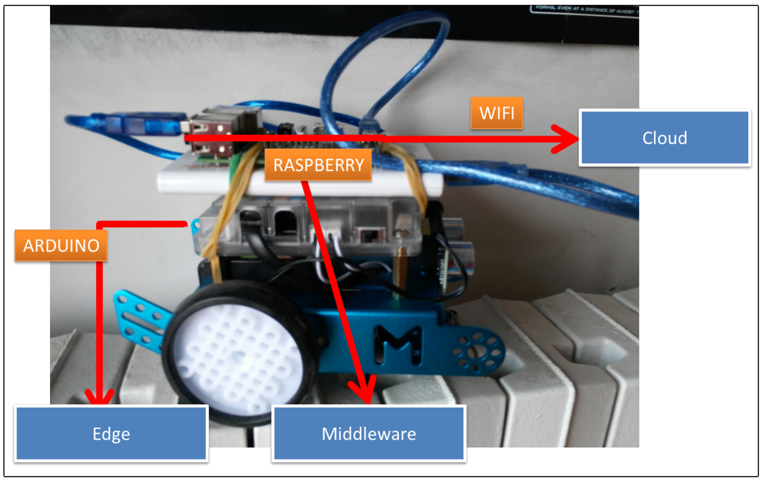
[4] The file is available in `it.unibo.issMaterial/issdocs/Material`.

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.

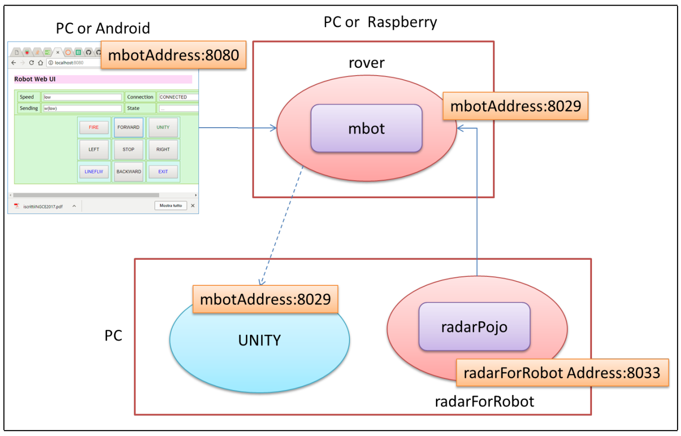
2.1.2 The mbot robot .

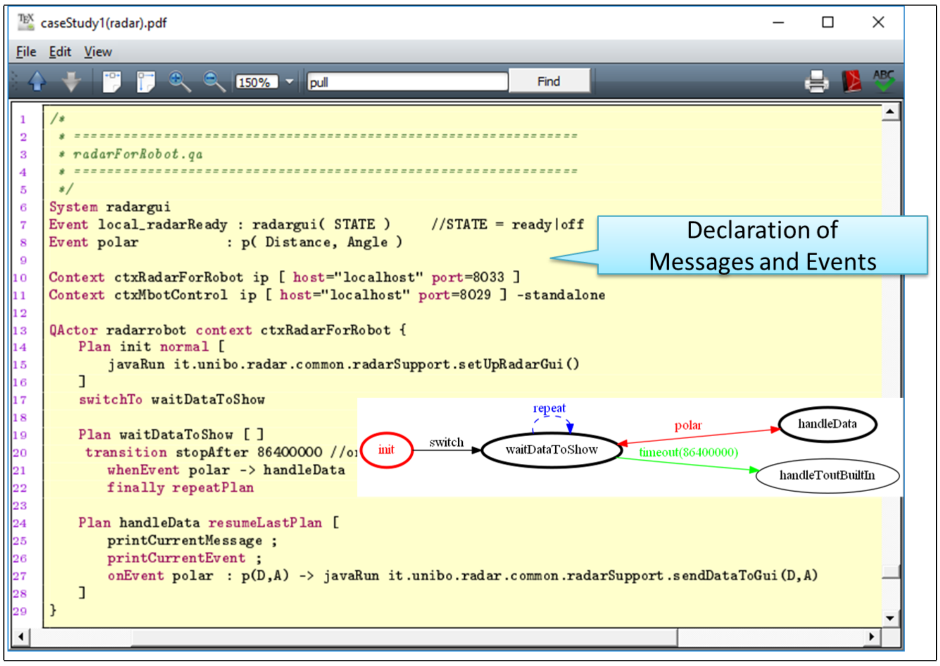
The mbot architecture is an example of a IOT architecture in which the edge part is implemented on Arduino, the middleware part is implemented on a RaspberryPi and the cloud part is implemented on a conventional PC.



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.





2.1.3 The real sonar .