



**POLITECNICO
DI MILANO**

IoT: Smart Bracelets

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1 Introduction

A Project Presentation

The aim of this project is to design, implement and test a software prototype for a set of smart bracelets. These bracelets are used by parents to keep track of their children's position and to alert them when a child goes too far. Parent and child bracelets are coupled together in order to exchange these alerts. The operation of the smart bracelet couple is as follows:

- Pairing phase: at startup, the parent's bracelet and the child's bracelet broadcast a 20-char random key used to uniquely couple the two devices. The same random key is pre-loaded at production time on the two devices: upon reception of a random key, a device checks whether the received random key is equal to the stored one; if yes, it stores the address of the source device in memory. Then, a special message is transmitted (in unicast) to the source device to stop the pairing phase and move to the next step.
- Operation mode: in this phase, the parent's bracelet listen for messages on the radio and accepts only messages coming from the child's bracelet. The child's bracelet periodically transmits INFO messages (one message every 10 seconds), containing the position (X, Y) of the child and an estimate of his/her kinematic status (STANDING, WALKING, RUNNING, FALLING).
- Alert Mode: upon reception of an INFO message, the parent's bracelet reads the content of the message. If the kinematic status is FALLING, the bracelet sends a FALL alarm, reporting the position (X, Y) of the children.
If the parent's bracelet does not receive any message, after one minute from the last received message, a MISSING alarm is sent reporting the last position received.

B Application structure

In the header file we have defined the structure that is used as the message payload. It contains the the type and the ID of the message along with the basic data of the bracelet such as the position and the status.

We also defined a set of predefined keys used in the pairing phase and a generator that allocates them to couples of bracelets. Finally, we assigned numbers to each type of message and status. In the module file we implemented all the logic regarding the exchange of messages, timer events and the initial pairing phase. In the configuration file we linked all the interfaces of the module with the components defined.

2 Implementation

A Pairing Mode

At first, the parent bracelet and the child bracelet begin the pairing session. A variable called "phase" indicates the status of the pairing phase, starting from 0. When the boot phase is done, the TPairing timer is invoked with a period of 500ms and "phase" is set to 0. As the timer fires, both parent and child bracelets send the pairing message that contains the random key. Upon receiving the message, a confirmation is sent to the other bracelets and "phase" is set to 1 proving that a couple of bracelets is found and the pairing is completed.

After receiving the confirmation the TPairing timer is stopped and both bracelets waits for the acknowledgmet of the previous message (the confirmation one).

Time	Mote	Message
00:04.320	ID:2	Application correctly booted.
00:04.323	ID:2	Parent: pairing phase started
00:04.432	ID:4	Application correctly booted.
00:04.435	ID:4	Parent: pairing phase started
00:04.466	ID:1	Application correctly booted.
00:04.469	ID:1	Child: pairing phase started
00:04.816	ID:2	Radio: pairing packet sent to bracelet KGXQBDgRLJLF92jbKw58
00:04.826	ID:1	Radio: message for pairing initialization received (phase 0). Address: 2
00:04.830	ID:1	Radio: sending pairing confirmation to node 2
00:04.837	ID:1	Radio: pairing ack received
00:04.838	ID:2	Radio: message for pairing confirmation received (phase 1)
00:04.928	ID:4	Radio: pairing packet sent to bracelet Xq7sVPILQUpdMuEGMlnN
00:04.962	ID:1	Radio: pairing packet sent to bracelet KGXQBDgRLJLF92jbKw58
00:04.968	ID:1	Radio: info ack received
00:04.970	ID:2	Radio: message for pairing initialization received (phase 0). Address: 1
00:04.974	ID:2	Radio: sending pairing confirmation to node 1
00:04.977	ID:2	Radio: pairing ack received
00:04.978	ID:1	Radio: message for pairing confirmation received (phase 1)
00:04.983	ID:3	Application correctly booted.
00:04.986	ID:3	Child: pairing phase started
00:05.416	ID:4	Radio: pairing packet sent to bracelet Xq7sVPILQUpdMuEGMlnN
00:05.430	ID:3	Radio: message for pairing initialization received (phase 0). Address: 4
00:05.434	ID:3	Radio: sending pairing confirmation to node 4
00:05.441	ID:3	Radio: pairing ack received
00:05.442	ID:4	Radio: message for pairing confirmation received (phase 1)
00:05.479	ID:3	Radio: pairing packet sent to bracelet Xq7sVPILQUpdMuEGMlnN
00:05.488	ID:3	Radio: info ack received
00:05.490	ID:4	Radio: message for pairing initialization received (phase 0). Address: 3
00:05.494	ID:4	Radio: sending pairing confirmation to node 3
00:05.502	ID:4	Radio: pairing ack received
00:05.503	ID:3	Radio: message for pairing confirmation received (phase 1)

At last, when the pairing ack is received, "phase" is set to 2 meaning that the bracelets are going into the operational mode and the timers are booted.

B Operational Mode

Every 10 seconds, the child bracelet send to the parent one an info message that contains the position (represented by two variables X and Y) and the child status (0 STANDING, 1 WALKING, 2 RUNNING and 3 FALLING). The status is randomly chosen following the requirements for this project. All the messages waits for an ack from the parent bracelets and in case of a missing confirmation, 3 attempts are made before printing an error message.

In the parent's bracelet at each info message received the current status is updated by a function that also triggers the T60 timer.

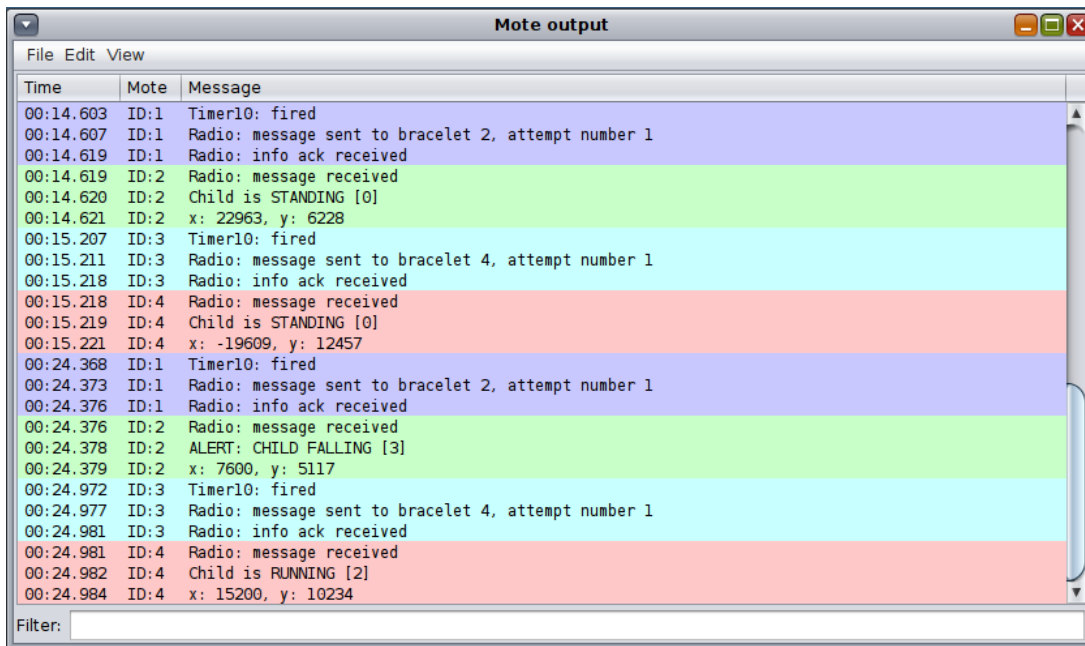
C Alert Mode

In case of a message with status FALLING, the bracelet enters the Alert Mode and shows a FALL message reporting the position of the child's bracelet. In the update-status function, after receiving an info message from the child bracelet, a 60 seconds timer is booted. If the timer fires, meaning that no info messages were sent in the last minute, an ALERT message is shown along with the last know position.

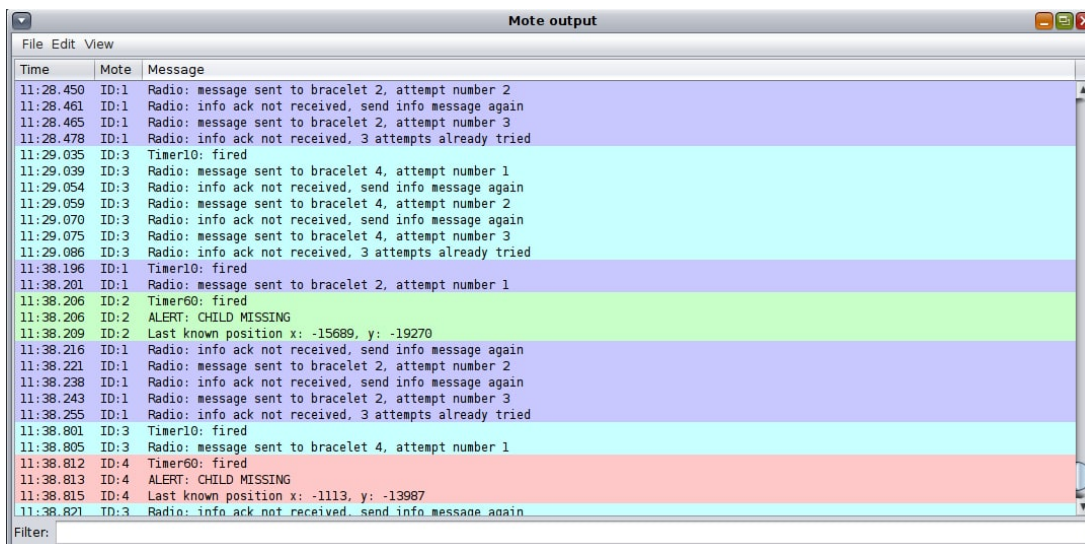
3 Cooja Simulation and Node-Red

Here below we report two screenshots from the Cooja simulation and one from Node-Red, one representing the exchange of info message in the operational mode and the other one shows the attempt to send messages to an out-of-range bracelet. The entire simulation is run with four motes, making two different couples of parent-child bracelets. The alert mode is simulated by

placing one of the motes out of the range of the other one. In Node-Red, messages are received on a TCP port and then filtered by a function to show the alerts.



Time	Mote	Message
00:14.603	ID:1	Timer10: fired
00:14.607	ID:1	Radio: message sent to bracelet 2, attempt number 1
00:14.619	ID:1	Radio: info ack received
00:14.619	ID:2	Radio: message received
00:14.620	ID:2	Child is STANDING [0]
00:14.621	ID:2	x: 22963, y: 6228
00:15.207	ID:3	Timer10: fired
00:15.211	ID:3	Radio: message sent to bracelet 4, attempt number 1
00:15.218	ID:3	Radio: info ack received
00:15.218	ID:4	Radio: message received
00:15.219	ID:4	Child is STANDING [0]
00:15.221	ID:4	x: -19609, y: 12457
00:24.368	ID:1	Timer10: fired
00:24.373	ID:1	Radio: message sent to bracelet 2, attempt number 1
00:24.376	ID:1	Radio: info ack received
00:24.376	ID:2	Radio: message received
00:24.378	ID:2	ALERT: CHILD FALLING [3]
00:24.379	ID:2	x: 7600, y: 5117
00:24.972	ID:3	Timer10: fired
00:24.977	ID:3	Radio: message sent to bracelet 4, attempt number 1
00:24.981	ID:3	Radio: info ack received
00:24.981	ID:4	Radio: message received
00:24.982	ID:4	Child is RUNNING [2]
00:24.984	ID:4	x: 15200, y: 10234



Time	Mote	Message
11:28.450	ID:1	Radio: message sent to bracelet 2, attempt number 2
11:28.461	ID:1	Radio: info ack not received, send info message again
11:28.465	ID:1	Radio: message sent to bracelet 2, attempt number 3
11:28.478	ID:1	Radio: info ack not received, 3 attempts already tried
11:29.035	ID:3	Timer10: fired
11:29.039	ID:3	Radio: message sent to bracelet 4, attempt number 1
11:29.054	ID:3	Radio: info ack not received, send info message again
11:29.059	ID:3	Radio: message sent to bracelet 4, attempt number 2
11:29.070	ID:3	Radio: info ack not received, send info message again
11:29.075	ID:3	Radio: message sent to bracelet 4, attempt number 3
11:29.086	ID:3	Radio: info ack not received, 3 attempts already tried
11:38.196	ID:1	Timer10: fired
11:38.201	ID:1	Radio: message sent to bracelet 2, attempt number 1
11:38.206	ID:2	Timer60: fired
11:38.206	ID:2	ALERT: CHILD MISSING
11:38.209	ID:2	Last known position x: -15689, y: -19270
11:38.216	ID:1	Radio: info ack not received, send info message again
11:38.221	ID:1	Radio: message sent to bracelet 2, attempt number 2
11:38.238	ID:1	Radio: info ack not received, send info message again
11:38.243	ID:1	Radio: message sent to bracelet 2, attempt number 3
11:38.255	ID:1	Radio: info ack not received, 3 attempts already tried
11:38.801	ID:3	Timer10: fired
11:38.805	ID:3	Radio: message sent to bracelet 4, attempt number 1
11:38.812	ID:4	Timer60: fired
11:38.813	ID:4	ALERT: CHILD MISSING
11:38.815	ID:4	Last known position x: -1113, y: -13987
11:38.821	ID:3	Radio: info ack not received, send info message again

