

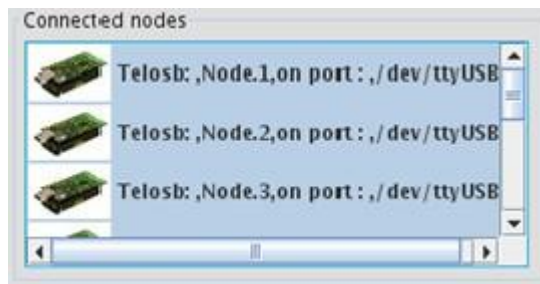



# A Framework for Benchmarking Link Quality Estimators

## Using ExpCtrApp application



### - Steps to perform an experiment

1. Connect a set of motes to the PC. They will be automatically detected by the application and displayed in the **List of Connected Motes** (picture below)
2. Select the motes that will be involved in the experiment, from the **List of Connected Motes**, using the following interface,




3. Click on the button  to effectively add the selected motes.
4. The **List of the Selected Motes** (that will be involved in the experiment) appears in the following interface :



5. If you need to remove one or more motes from the **List of the Selected Motes**, then select the mote(s) from that list and click in the button 
6. Click on the button  to update the **List of the Selected Motes**, if you have connected/disconnected some motes to/from the PC.
7. Install the nesC code on the motes:

a. Click on the button  to browse the nesC binary code:  
**ExpCtrApp\Java\_Code\build\telosb\main**

b. Click on the button  to install the program in the all selected motes.

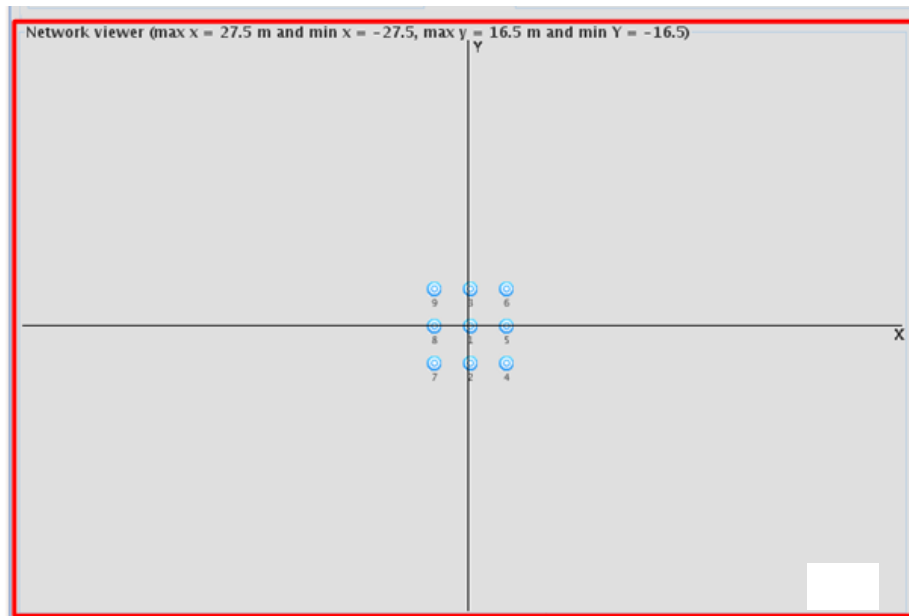
8. Set up the network and the experiment parameters using the following interface:


**Experiment Setup**

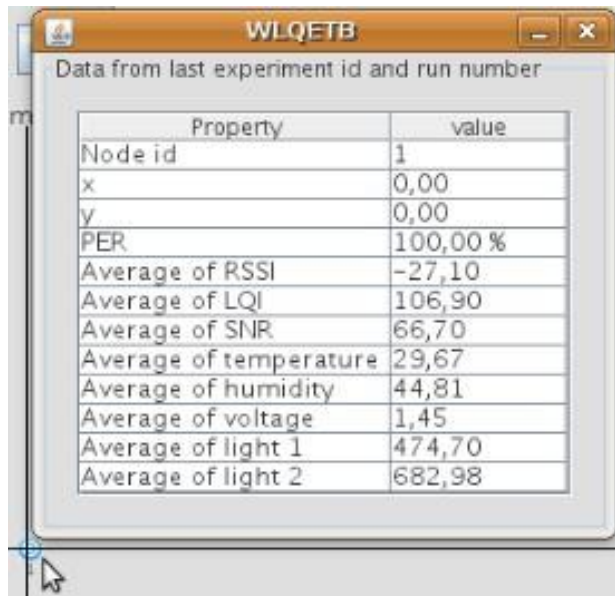
Experiment ID	PT20090707_179	Mote type	Telosb
Experiment run ...	1	Traffic pattern	Synchronized
Date - Time	07/07/09 15:22	Channel	25
Country	Portugal	Tx power	0
City	Porto	Number of packets	100
Topology	Grid	Packet size	28
Environment	Outdoor	Enable Retx	<input type="radio"/> Yes <input checked="" type="radio"/> No
Mote type	Telosb	Retx count	0
Description		Min Interpkt Time	62.0 ms
		Inter packet interval	

9. Click on the button  to start the experiment.

10. The network viewer shows the distribution of the selected motes during the experiment.

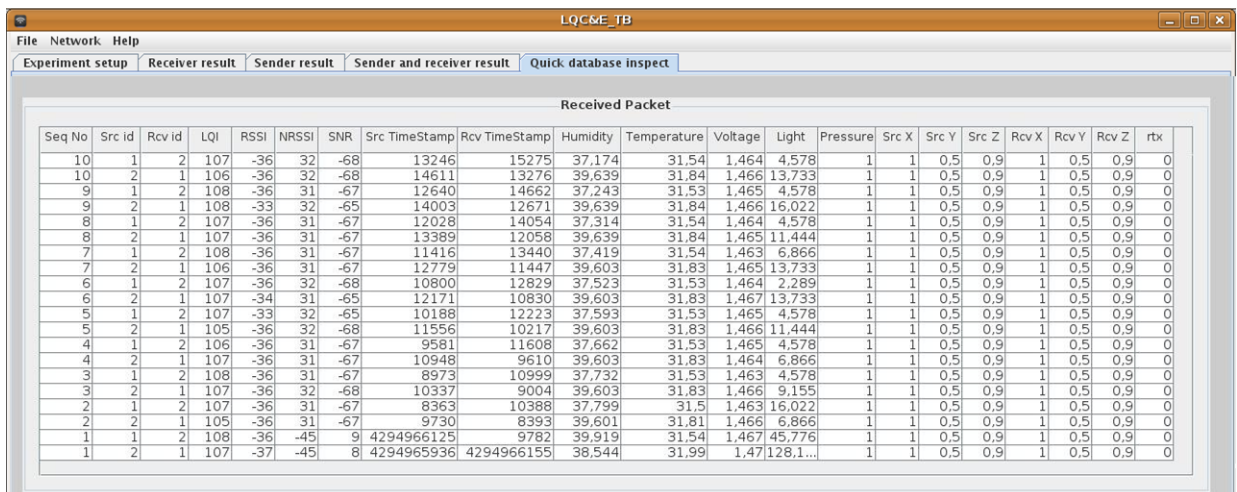


11. If you click on one mote , relevant information about the mote will appear as shown by this figure:



Property	value
Node id	1
x	0,00
y	0,00
PER	100,00 %
Average of RSSI	-27,10
Average of LQI	106,90
Average of SNR	66,70
Average of temperature	29,67
Average of humidity	44,81
Average of voltage	1,45
Average of light 1	474,70
Average of light 2	682,98

12. The quick database inspect shows the collected data in **real-time** during the experiment, as show the figure below:



Received Packet																				
Seq No	Src id	Rcv id	LQI	RSSI	NRSSI	SNR	Src TimeStamp	Rcv TimeStamp	Humidity	Temperature	Voltage	Light	Pressure	Src X	Src Y	Src Z	Rcv X	Rcv Y	Rcv Z	rtx
10	1	2	107	-36	32	-68	13246	15275	37,174	31,54	1,464	4,578	1	1	0,5	0,9	1	0,5	0,9	0
10	2	1	106	-36	32	-68	14611	13276	39,639	31,84	1,466	13,733	1	1	0,5	0,9	1	0,5	0,9	0
9	1	2	108	-36	31	-67	12640	14662	37,243	31,53	1,465	4,578	1	1	0,5	0,9	1	0,5	0,9	0
9	2	1	108	-33	32	-65	14003	12671	39,639	31,84	1,466	16,022	1	1	0,5	0,9	1	0,5	0,9	0
8	1	2	107	-36	31	-67	12028	14054	37,314	31,54	1,464	4,578	1	1	0,5	0,9	1	0,5	0,9	0
8	2	1	107	-36	31	-67	13389	12058	39,639	31,84	1,465	11,444	1	1	0,5	0,9	1	0,5	0,9	0
7	1	2	108	-36	31	-67	11416	13440	37,419	31,54	1,463	6,866	1	1	0,5	0,9	1	0,5	0,9	0
7	2	1	106	-36	31	-67	12779	11447	39,603	31,83	1,465	13,733	1	1	0,5	0,9	1	0,5	0,9	0
6	1	2	107	-36	32	-68	10800	12829	37,523	31,53	1,464	2,289	1	1	0,5	0,9	1	0,5	0,9	0
6	2	1	107	-34	31	-65	12171	10830	39,603	31,83	1,467	13,733	1	1	0,5	0,9	1	0,5	0,9	0
5	1	2	107	-33	32	-65	10188	12223	37,593	31,53	1,465	4,578	1	1	0,5	0,9	1	0,5	0,9	0
5	2	1	105	-36	32	-68	11556	10217	39,603	31,83	1,466	11,444	1	1	0,5	0,9	1	0,5	0,9	0
4	1	2	106	-36	31	-67	9581	11608	37,662	31,53	1,465	4,578	1	1	0,5	0,9	1	0,5	0,9	0
4	2	1	107	-36	31	-67	10948	9610	39,603	31,83	1,464	6,866	1	1	0,5	0,9	1	0,5	0,9	0
3	1	2	108	-36	31	-67	8973	10999	37,732	31,53	1,463	4,578	1	1	0,5	0,9	1	0,5	0,9	0
3	2	1	107	-36	32	-68	10337	9004	39,603	31,83	1,466	9,155	1	1	0,5	0,9	1	0,5	0,9	0
2	1	2	107	-36	31	-67	8363	10388	37,799	31,5	1,463	16,022	1	1	0,5	0,9	1	0,5	0,9	0
2	2	1	105	-36	31	-67	9730	8393	39,601	31,81	1,466	6,866	1	1	0,5	0,9	1	0,5	0,9	0
1	1	2	108	-36	-45	9	4294966125	9782	39,919	31,54	1,467	45,776	1	1	0,5	0,9	1	0,5	0,9	0
1	2	1	107	-37	-45	8	42949665936	4294966155	38,544	31,99	1,47	128,1...	1	1	0,5	0,9	1	0,5	0,9	0

# Graphical User Interface for Performing Experiments

The screenshot shows the LQG&E\_TB graphical user interface. It features several main sections:

- Nodes reprogramming:** Contains two lists. The 'Connected nodes' list shows three Telosb nodes (Node 1, 2, 3) with their respective USB ports. The 'Selected nodes' list shows nine Telosb nodes (Node 1 through 9) with their respective USB ports. A callout 'Automatically detection of the motes' points to the 'Connected nodes' list, and another callout 'Selection of the motes' points to the 'Selected nodes' list.
- Install program:** A section with a 'Browse...' button and an 'Install the program in the selected nodes' button. A callout 'Motes reprogramming' points to this section.
- Network viewer:** A 2D coordinate system with X and Y axes. It displays a grid topology with nine nodes (represented by blue circles) arranged in a 3x3 grid. A callout 'Draw the network topology' points to this viewer.
- Experiment Setup:** A form containing various parameters for the experiment, including:
  - Experiment ID: PT20090707\_179
  - Experiment run: 1
  - Date - Time: 07/07/09 15:22
  - Country: Portugal
  - City: Porto
  - Topology: Grid
  - Environment: Outdoor
  - Mote type: Telosb
  - Mote type: Telosb
  - Traffic pattern: Synchronized
  - Channel: 25
  - Tx power: 0
  - Number of packet: 100
  - Packet size: 28
  - Enable Retx: No
  - Retx count: 5
  - Min Interpkt Time: 62.0 ms
  - Inter packet intervalA callout 'Experimental information' points to the 'Experiment ID' field, and another callout 'Start experiment' points to the 'Start' button. A callout 'Select the network parameters' points to the 'Experiment Setup' form.

## – Steps to analyze the experiment data

After the experiment finishes, you can use the following functionalities for an off-line and quick analysis of the experiment data. Experiment data analysis using the ExpCtrApp is just to have an idea on the collected data during the experiment. A thorough analysis is provided by the DataAnlApp Matlab application

Follow a summary of the main steps to analyze the collected data using the ExpCtrApp java application.

1. ExpCtrApp provides the following interfaces for the experiment data analysis : **Receiver Results**, **Sender Results** and **Sender and Receiver Results**. Select for instance the interface **Receiver Results** interface. This interface looks as the follow picture
2. Select an Experiment Id, and a Run Number for this experiment. Note that one experiment (defined by a set of settings) can be run many times.

**Load Experiment data**

1. Select an experiment ID  5. Select the type  Average  Time line

2. Select a run number  6. Select an item to generate the corresponding graph

3. Select a sender ID

4. Select a receiver ID

3. To delete data related to the selected experiment having that run number, just click on the button
4. Select a **sender Id**, one choose **all** senders
5. Select a **receiver id**, one choose **all** receivers

**Load Experiment data**

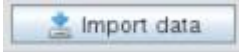
1. Select an experiment ID  5. Select the type  Average  Time line

2. Select a run number  6. Select an item to generate the corresponding graph

3. Select a sender ID

4. Select a receiver ID

6. Import data according to the selected information by clicking on the button



7. Visualize some graphs:

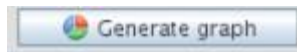
a. Select a type of graph



b. Select the metric



c. Click on the button



**Load Experiment data**

1. Select an experiment ID	<input type="text" value="PT20090819_11"/>	5. Select the type	<input checked="" type="radio"/> Average <input type="radio"/> Time line
2. Select a run number	<input type="text" value="1"/>	6. Select an item to generate the corresponding graph	
3. Select a sender ID	<input type="text" value="1"/>		
4. Select a receiver ID	<input type="text" value="2"/>		

A vertical dropdown menu with a light blue border. The top item is "PACKET RECEPTION RATE" and is highlighted in blue. Below it are "PACKET RECEPTION RATE - BAR", "REGION OF MOTES", and "LQI". On the right side of the menu, there are four small navigation icons: an upward-pointing triangle, a horizontal line, a downward-pointing triangle, and a square.

## Graphical User Interface to Perform Off-line Analysis of experiment data

Selection of parameters to import data or create graph or delete data

Experimental informations from imported experiment

The screenshot displays the LQCM\_E\_TB software interface. The 'Load Experiment data' section includes several dropdown menus for selecting an experiment ID (PT20090819\_11), run number (1), sender ID (1), and receiver ID (2). It also features radio buttons for 'Average' and 'Time line', and a list of parameters to generate a graph, with 'PACKET RECEPTION RATE' selected. Below these are buttons for 'del run', 'Import data', and 'Generate graph'.

The 'Experiment-related info' section shows a table of properties and values:

Property	value
Exp id	PT20090819_11
Exp run nbr	1
Date	2009-08-19
Time	18:25:41
Payload size	28
Inter pkt time	1024
Nbr sent pkt	100
Nbr nodes	49
Trans power	3
Channel	26

Next to this is a 'Comments' field containing text about the scenario and burst mode.

The 'Received Messages' section displays a large table of data:

Seq Number	Sender	Receiver	LQI	RSSI	NRSSI	SNR	Src TimeStamp	Rcv TimeStamp	Rtx	Humidity	Temperature	Voltage	Light1	Light2	Sx
99	1	2	89	-90	-97	6.03347	12215818	2878420	0	82,27	19.63	1,489	6,87	9,16	0
98	1	2	75	-91	-96	3.34911	12214778	2877379	0	82,27	19.63	1,489	6,87	9,16	0
97	1	2	86	-91	-96	3.34911	12213741	2876339	0	82,27	19.63	1,489	6,87	9,16	0
96	1	2	87	-91	-96	3.34911	12212704	2875302	0	82,27	19.63	1,489	6,87	9,16	0
95	1	2	98	-90	-96	4.74372	12211670	2874264	0	82,27	19.63	1,489	6,87	9,16	0
94	1	2	88	-90	-96	4.74372	12210637	2873231	0	82,27	19.63	1,489	6,87	9,16	0
93	1	2	94	-89	-96	6.03347	12209597	2872198	0	82,27	19.63	1,489	6,87	9,16	0
92	1	2	99	-90	-95	3.34911	12208563	2871157	0	82,27	19.63	1,489	6,87	9,16	0
91	1	2	100	-89	-96	6.03347	12207529	2870124	0	82,27	19.63	1,489	6,87	9,16	0
90	1	2	99	-89	-93	1.79519	12206497	2869090	0	82,27	19.63	1,489	6,87	9,16	0
89	1	2	100	-89	-96	6.03347	12205460	2868057	0	82,27	19.63	1,489	6,87	9,16	0
88	1	2	99	-89	-97	7.2506	12204419	2867020	0	82,27	19.63	1,489	6,87	9,16	0
87	1	2	98	-89	-96	6.03347	12203382	2865980	0	82,27	19.63	1,489	6,87	9,16	0
86	1	2	97	-88	-97	8.41565	12202348	2864943	0	82,27	19.63	1,489	6,87	9,16	0
85	1	2	99	-88	-96	7.2506	12201307	2863908	0	82,27	19.63	1,489	6,87	9,16	0
84	1	2	98	-88	-96	7.2506	12200273	2862868	0	82,27	19.63	1,489	6,87	9,16	0
83	1	2	101	-88	-96	7.2506	12199232	2861834	0	82,27	19.63	1,489	6,87	9,16	0
82	1	2	89	-91	-96	3.34911	12198140	2860793	3	82,27	19.63	1,489	6,87	9,16	0
81	1	2	83	-90	-96	4.74372	12197108	2859701	0	82,27	19.63	1,489	6,87	9,16	0
80	1	2	75	-91	-96	3.34911	12196054	2858669	1	82,27	19.63	1,489	6,87	9,16	0
79	1	2	82	-92	-96	1.79519	12194909	2857592	5	82,27	19.63	1,489	6,87	9,16	0
78	1	2	74	-92	-96	1.79519	12193855	2856448	0	82,27	19.63	1,489	6,87	9,16	0

Imported data