

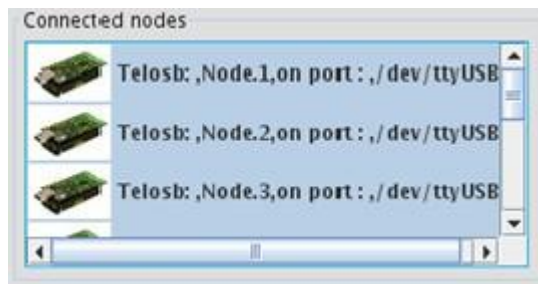



A Framework for Benchmarking Link Quality Estimators

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.

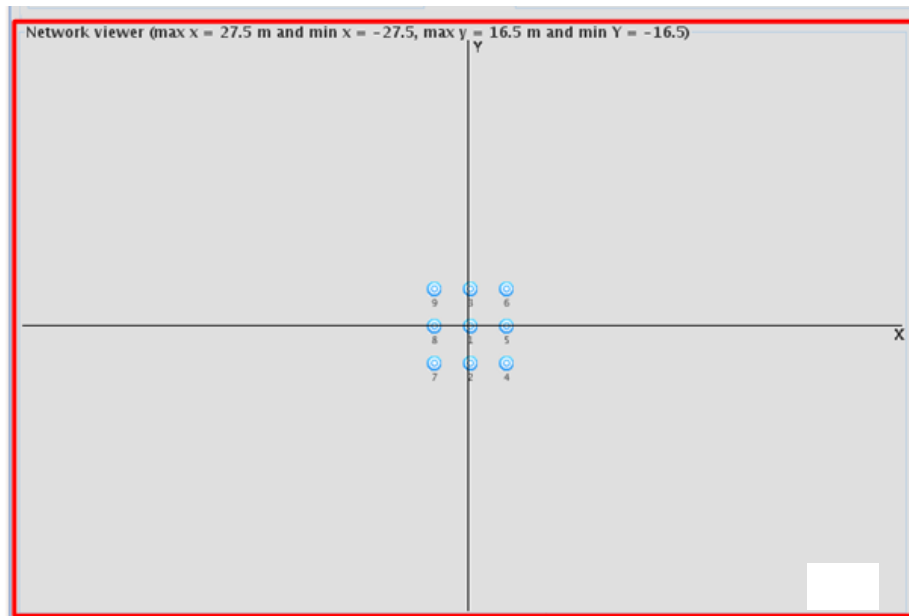
8. Set up the network and the experiment parameters using the following interface:


Experiment Setup

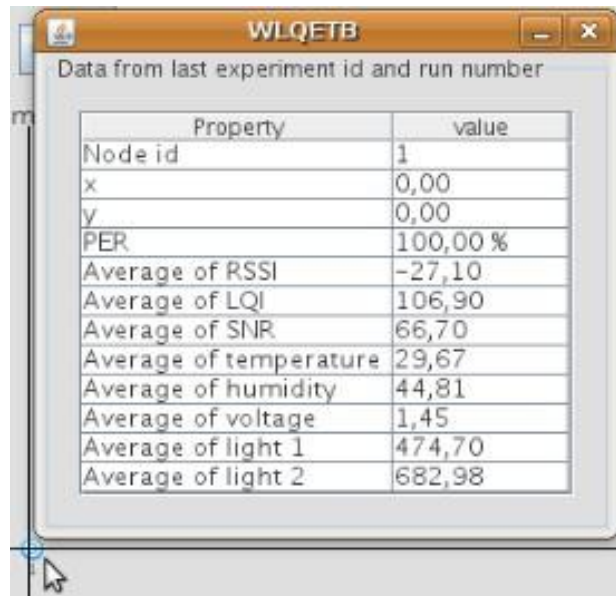
Experiment ID	PT20090707_179	Mote type	Telosb
Experiment run ...	1	Traffic pattern	Synchronized
Date - Time	07/07/09 15:22	Channel	25
Country	Portugal	Tx power	0
City	Porto	Number of packets	100
Topology	Grid	Packet size	28
Environment	Outdoor	Enable Retx	<input type="radio"/> Yes <input checked="" type="radio"/> 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.

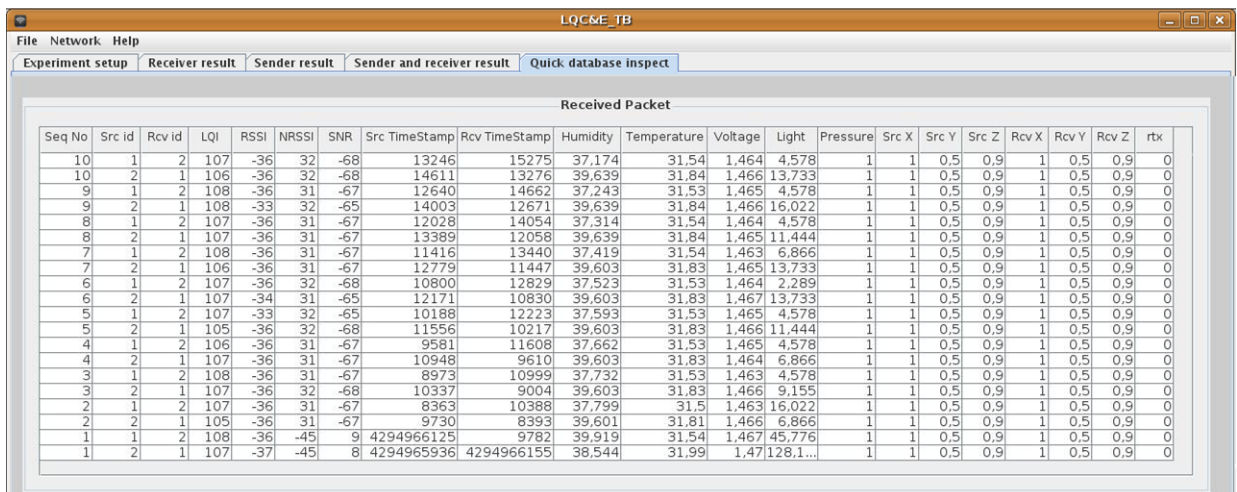


11. If you click on one mote , relevant information about the mote will appear as shown by this figure:



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 displays the LQG&E_TB graphical user interface, which is used for configuring and executing network experiments. The interface is divided into several functional areas:

- Nodes reprogramming:** Located at the top left, it contains two lists: "Connected nodes" and "Selected nodes". Both lists show Telosb nodes with their respective USB ports (e.g., "/dev/ttyUSB1" through "/dev/ttyUSB9").
- Install program:** A section on the right side of the top half, featuring a "Browse..." button and an "Install the program in the selected nodes" button.
- Network viewer:** A central 2D plot showing a network topology. The axes are labeled X and Y, with a bounding box of (max x = 27.5 m and min x = -27.5, max y = 16.5 m and min y = -16.5). Several nodes are plotted as small circles with numbers 1 through 9.
- Experiment Setup:** A panel on the right side of the bottom half, containing various configuration fields:
 - 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
 - Description: (empty text area)
 - Mote type: Telosb
 - Traffic pattern: Synchronized
 - Channel: 25
 - Tx power: 0
 - Number of packet: 100
 - Packet size: 28
 - Enable Retx: No (selected)
 - Retx count: (empty field)
 - Min Interpkt Time: 62.0 ms
 - Inter packet interval: (empty field)
- Start:** A prominent button at the bottom center of the Experiment Setup panel.

Red callout boxes with arrows point to these key features, with the following labels:

- Automatically detection of the motes** (points to the "Connected nodes" list)
- Selection of the motes** (points to the "Selected nodes" list)
- Motes reprogramming** (points to the "Install program" section)
- Draw the network topology** (points to the "Network viewer" plot)
- Start experiment** (points to the "Start" button)
- Select the network parameters** (points to the "Experiment Setup" panel)
- Experimental information** (points to the "Experiment Setup" panel)

- 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

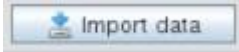
1. Select an experiment ID 5. Select the type Average Time line

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:

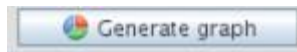
a. Select a type of graph



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"/>		<input type="text" value="PACKET RECEPTION RATE"/>
4. Select a receiver ID	<input type="text" value="2"/>		<input type="text" value="PACKET RECEPTION RATE - BAR"/>
			<input type="text" value="REGION OF MOTES"/>
			<input type="text" value="LQI"/>

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. At the top, there are menu options: File, Network, Help. Below the menu is a tabbed interface with 'Experiment setup', 'Receiver result', 'Sender result', 'Sender and receiver result', and 'Quick database inspect'. The 'Experiment setup' tab is active, showing a 'Load Experiment data' section with six numbered steps and a list of parameters to select. A red box highlights these selection options. To the right, the 'Experiment-related info' section shows a table of properties and values, and a 'Comments' field. A red box highlights this information. Below these sections is a 'Received Messages' table with columns for Seq Number, Sender, Receiver, LQI, RSSI, NRSSI, SNR, Src TimeStamp, Rcv TimeStamp, Rtx, Humidity, Temperature, Voltage, Light1, Light2, and Sx. A red box highlights the entire table. At the bottom, a red box highlights the 'Imported data' label.

Load Experiment data

- Select an experiment ID: PT20090819_11
- Select a run number: 1
- Select a sender ID: 1
- Select a receiver ID: 2
- Select the type: Average Time line
- Select an item to generate the corresponding graph: PACKET RECEPTION RATE

Experiment-related info

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

Comments

Scenario 3, Burst mode 3, ipi 1024 channel 26 and tx = -25dbm. In the garden on afternoon. X = 3m and inter circle 0,75m. Burst count = 2 and burst window size = 50

Received Messages

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