Comparing MAC Layer Implementations using Contiki-OS

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Parameters under Observation

Parameters Under Observation

- Packet Reception Rate (PRR):Percent of received packets in an interval
  - related to throughput
  - if PRR is low, Packets dropped High
  - if PRR is low, overall throughput is low
- Average Duty-Cycle of sensor node
  - pertaining to Power Consumption of nodes
  - Lower the duty cycle less power consumed and longer lifetime of node
  - energy savings high when node is sleeping

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Required Firmware

Required Firmware

We use the example mentioned in the following folder:
examples/ipv6/rpl-udp
The folder contains:

- **udp-server.c**: A UDP server with RPL[1] abilities with IPv6 addressing
- **udp-client.c**: A UDP client with RPL abilities with IPv6 addressing
- **rpl-udp-powertrace.csc**: Cooja simulator file for powertracing feature
- **rpl-udp.csc**: Cooja simulator file to understand RPL based routing of UDP packets in network

[1] Routing Protocol over Low-power Lossy Networks

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Steps for Configuration
- Simulation for ContikiMAC
- Results for ContikiMAC Simulation
- Simulation for CXMAC
- Results for CX-MAC Simulation

Steps

- For easy access of MAC and RDC (Radio Duty Cycling) layer, we make use of a **project-conf.h** file
- use the following (in the *ipv6/rpl-udp* folder):

```
$ gedit project-conf.h
```

Add the following configuration

- Channel Check Rate: 8 Hz
- MAC Layer: CSMA
- RDC Layer: ContikiMAC

```
#define NETSTACK_CONF_CHANNEL_CHECK_RATE 8

#define NETSTACK_CONF_MAC  csma_driver

#define NETSTACK_CONF_RDC  contikimac_driver
```

Steps

Do not forget to add the **project-conf.h** to the Makefile by adding this:

```
CFLAGS += -DPROJECT_CONF_H=\"project-conf.h\"
```

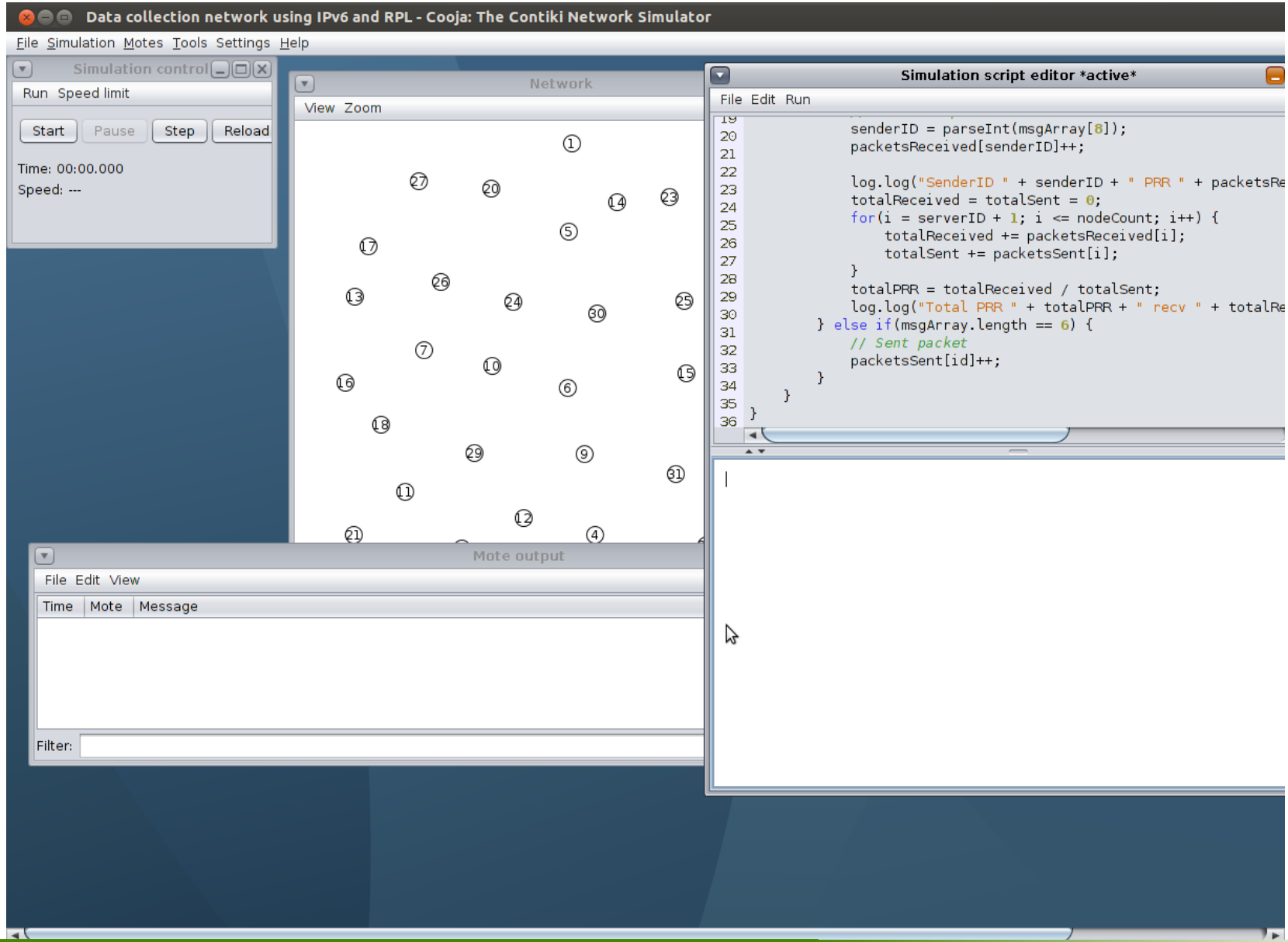
Previously mentioned configuration is **default** even if there is no **project-conf.h** mentioned in your work.
We use the available **rpl-udp-powertrace.csc** file for simulation.

- To make the Simulator run do the following the available .csc file:

  ```
  make TARGET=cooja rpl-udp-powertrace.csc
  ```

Or you can create your own simulation for e.g. One UDP Sink and 10 UDP clients

Cooja Simulator view

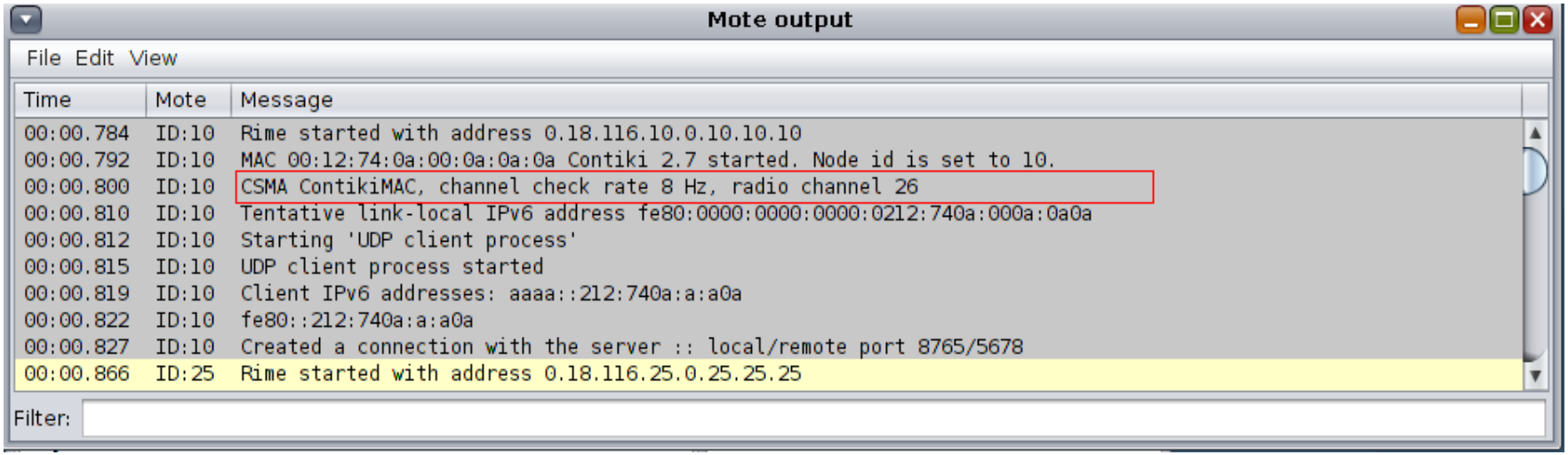


Simulation for ContikiMAC

Before starting the simulation:

- click on **View** in Network window and choose **Radio Traffic** and **Mote Type** options
- on the Toolbar, click on **Mote Radio Duty Cycle** and adjust the window to view all the motes
- Start the simulation and keep it on for 5 minutes (NOTE: don't rely on the time in the Simulator, use your Watch)
- Check on **Mote Output** window and observe the starting commands (scroll all the way to the top to see what the nodes are configured to)
  it should the **same as your project-conf.h file**
- Observe the values collected in the Radio duty cycle and save if for comparison (use Screenshot tool in the Applications)

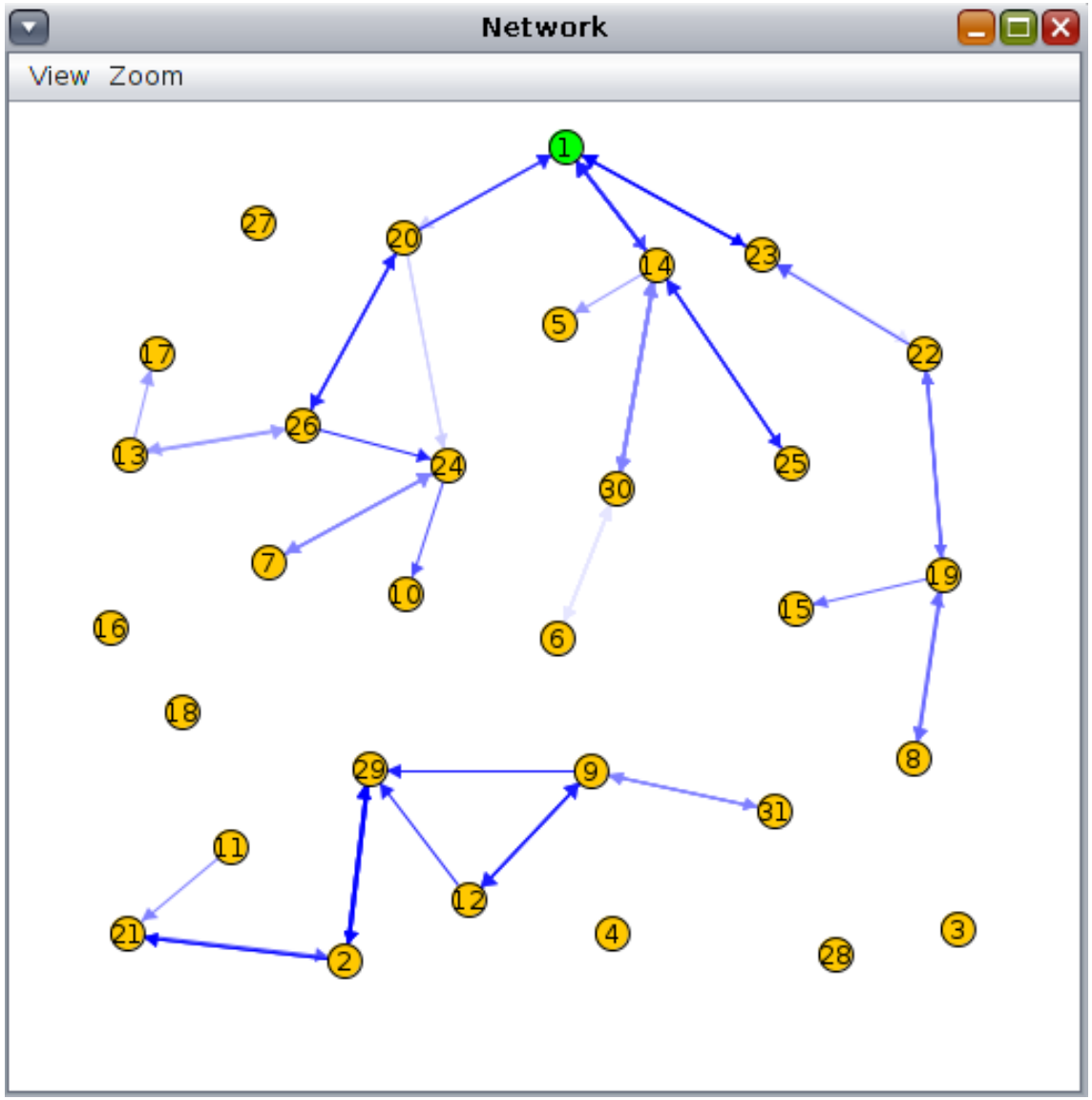
Mote Output for ContikiMAC Simulation



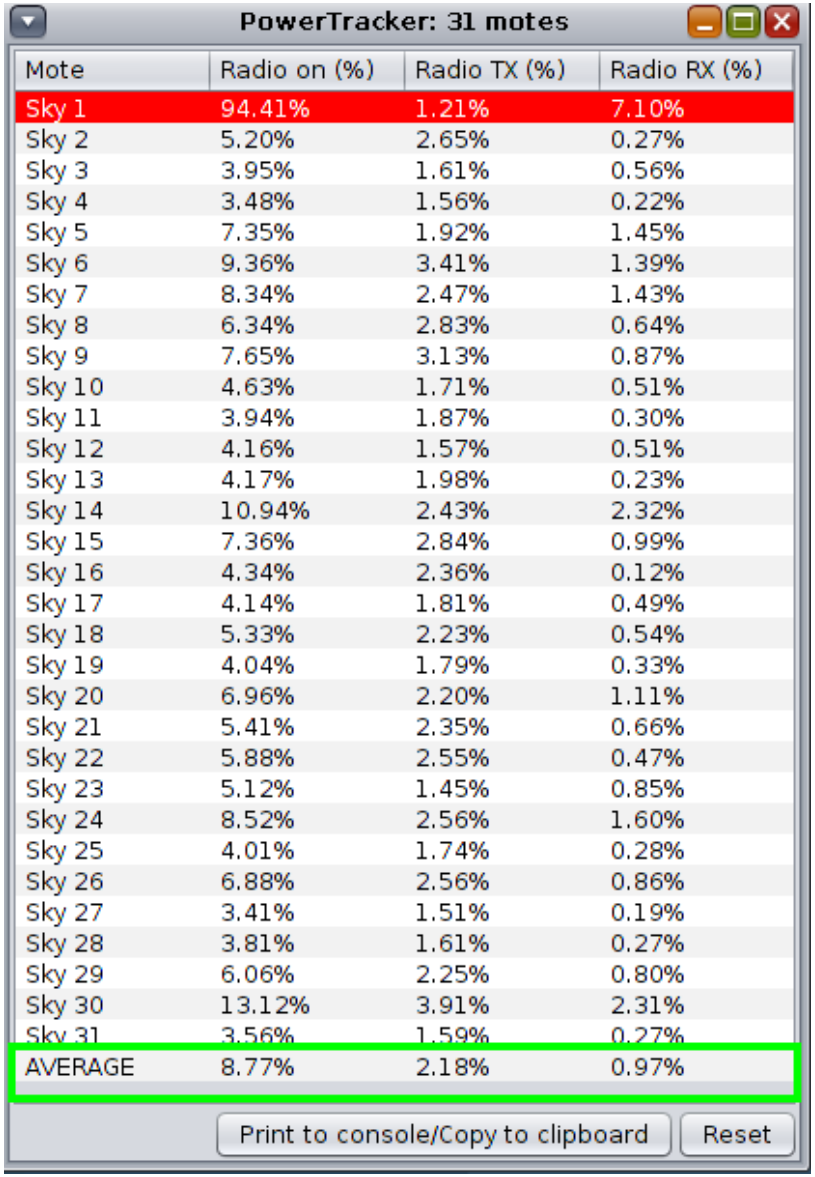
observe that all the motes are configured to:

- CSMA
- ContikiMAC
- Channel Check Rate 8 Hz
- Radio Channel number is 26

Network Topology for Simulation



Results for ContikiMAC



PowerTracker: 31 motes

Mote	Radio on (%)	Radio TX (%)	Radio RX (%)
Sky 1	94.41%	1.21%	7.10%
Sky 2	5.20%	2.65%	0.27%
Sky 3	3.95%	1.61%	0.56%
Sky 4	3.48%	1.56%	0.22%
Sky 5	7.35%	1.92%	1.45%
Sky 6	9.36%	3.41%	1.39%
Sky 7	8.34%	2.47%	1.43%
Sky 8	6.34%	2.83%	0.64%
Sky 9	7.65%	3.13%	0.87%
Sky 10	4.63%	1.71%	0.51%
Sky 11	3.94%	1.87%	0.30%
Sky 12	4.16%	1.57%	0.51%
Sky 13	4.17%	1.98%	0.23%
Sky 14	10.94%	2.43%	2.32%
Sky 15	7.36%	2.84%	0.99%
Sky 16	4.34%	2.36%	0.12%
Sky 17	4.14%	1.81%	0.49%
Sky 18	5.33%	2.23%	0.54%
Sky 19	4.04%	1.79%	0.33%
Sky 20	6.96%	2.20%	1.11%
Sky 21	5.41%	2.35%	0.66%
Sky 22	5.88%	2.55%	0.47%
Sky 23	5.12%	1.45%	0.85%
Sky 24	8.52%	2.56%	1.60%
Sky 25	4.01%	1.74%	0.28%
Sky 26	6.88%	2.56%	0.86%
Sky 27	3.41%	1.51%	0.19%
Sky 28	3.81%	1.61%	0.27%
Sky 29	6.06%	2.25%	0.80%
Sky 30	13.12%	3.91%	2.31%
Sky 31	3.56%	1.59%	0.27%
AVERAGE	8.77%	2.18%	0.97%

Print to console/Copy to clipboard | Reset

changing to CX-MAC

- before changing the RDC layer, close the current simulation and Cooja.
- do the following changes (via terminal):

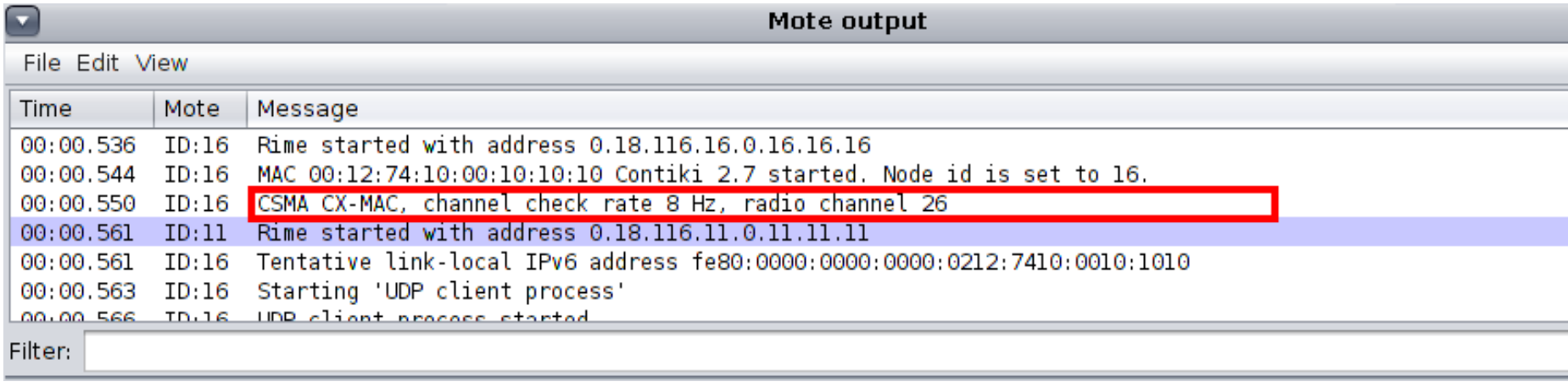
  ```
  #define NETSTACK_CONF_RDC  cxmac_driver
  ```

  and compile the program once again

  ```
  make TARGET=cooja rpl-udp-powertrace.csc
  ```

- follow the same step as previously mentioned and run the simulation

Mote Output for CXMAC



Observe that all the motes are configured as:

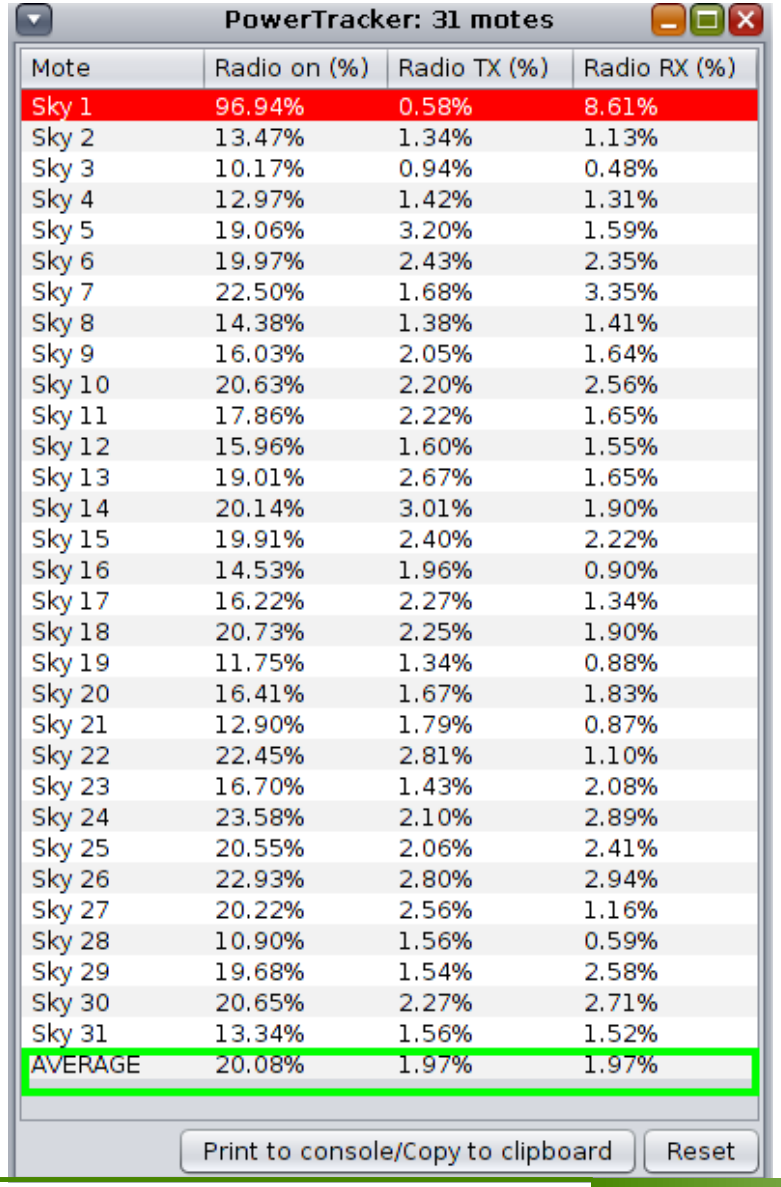
- CSMA
- CX-MAC
- Channel Check Rate 8 Hz
- Radio Channel number is 26

To View the Nodes IEEE 802.15.4 Radio interface

- in the Network window, right-click on any Mote
- in the drop down menu go to **More Tools for Sky ..**
- click on **Mote Interface Viewer**
- in the window click on drop down menu on the top right corner
- select **IEEE 802.15.4 Radio**

This window will show you what the selected mote is doing (Listening or Idle) and signal strength
In the end compare the **Average values** from the Radio Duty Cycle window for both CX-MAC and ContikiMAC.

Simulation for CX-MAC



PowerTracker: 31 motes

Mote	Radio on (%)	Radio TX (%)	Radio RX (%)
Sky 1	96.94%	0.58%	8.61%
Sky 2	13.47%	1.34%	1.13%
Sky 3	10.17%	0.94%	0.48%
Sky 4	12.97%	1.42%	1.31%
Sky 5	19.06%	3.20%	1.59%
Sky 6	19.97%	2.43%	2.35%
Sky 7	22.50%	1.68%	3.35%
Sky 8	14.38%	1.38%	1.41%
Sky 9	16.03%	2.05%	1.64%
Sky 10	20.63%	2.20%	2.56%
Sky 11	17.86%	2.22%	1.65%
Sky 12	15.96%	1.60%	1.55%
Sky 13	19.01%	2.67%	1.65%
Sky 14	20.14%	3.01%	1.90%
Sky 15	19.91%	2.40%	2.22%
Sky 16	14.53%	1.96%	0.90%
Sky 17	16.22%	2.27%	1.34%
Sky 18	20.73%	2.25%	1.90%
Sky 19	11.75%	1.34%	0.88%
Sky 20	16.41%	1.67%	1.83%
Sky 21	12.90%	1.79%	0.87%
Sky 22	22.45%	2.81%	1.10%
Sky 23	16.70%	1.43%	2.08%
Sky 24	23.58%	2.10%	2.89%
Sky 25	20.55%	2.06%	2.41%
Sky 26	22.93%	2.80%	2.94%
Sky 27	20.22%	2.56%	1.16%
Sky 28	10.90%	1.56%	0.59%
Sky 29	19.68%	1.54%	2.58%
Sky 30	20.65%	2.27%	2.71%
Sky 31	13.34%	1.56%	1.52%
AVERAGE	20.08%	1.97%	1.97%

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Result

Changes and Result

- change the data transmission interval to 1 or any value in seconds in **udp-client.c** in the following section:

```
#ifndef
#define PERIOD 1
#endif
```

  this will affect the PRR values and duty cycle values accordingly
- test a self created MAC protocol versus an already defined MAC layer (CXMAC or ContikiMAC)

RESULT: ContikiMAC is has better performance than the CX-MAC in terms of PRR and is more energy efficient for nodes (9 percent v/s 20 percent respectively).
The SINK node remains on for almost close to 100 percent since it keeps receiving packets from Clients.