Enhancements in the implementation of the Epidemic routing protocol.

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Major Enhancements

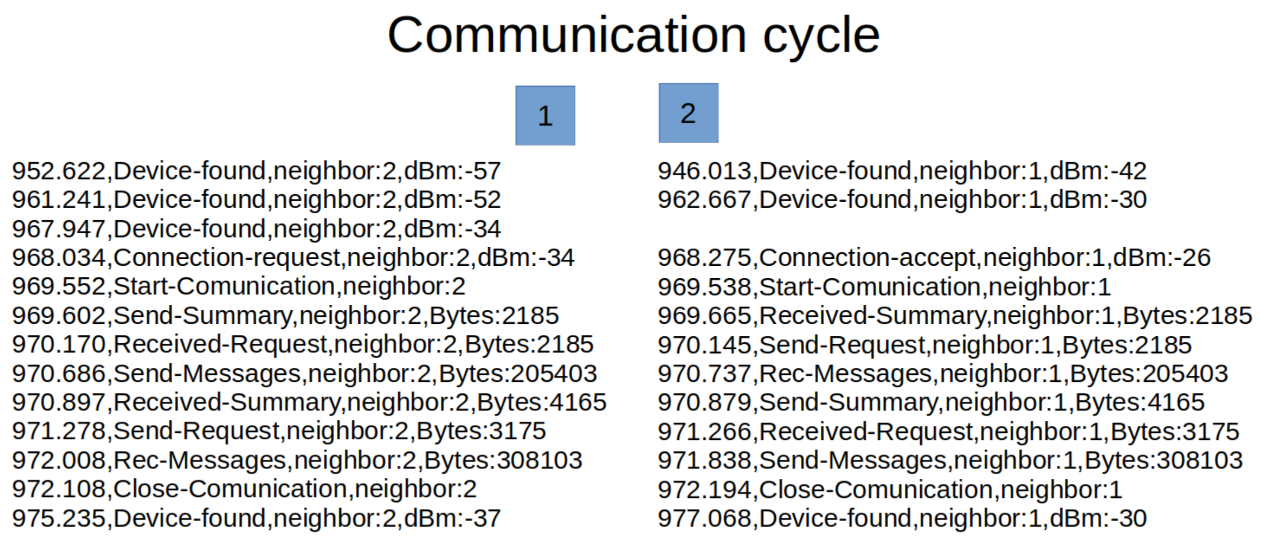
1 Request vector implementation and RSSI measurement

- In the new implementation a node can choose which messages it would like to receive by sending a Request vector before receiving messages.

- To guaranty the quality of the link between 2 nodes, a node requests a connection from a new discovered neighbor only if the RSSI of the the neighbor's beacon is higher than a threshold.

- For debugging and research purposes, a node saves the RSSI of the incoming packets in the log files after a link is established.

The following figure shows the events when two nodes are in contact.



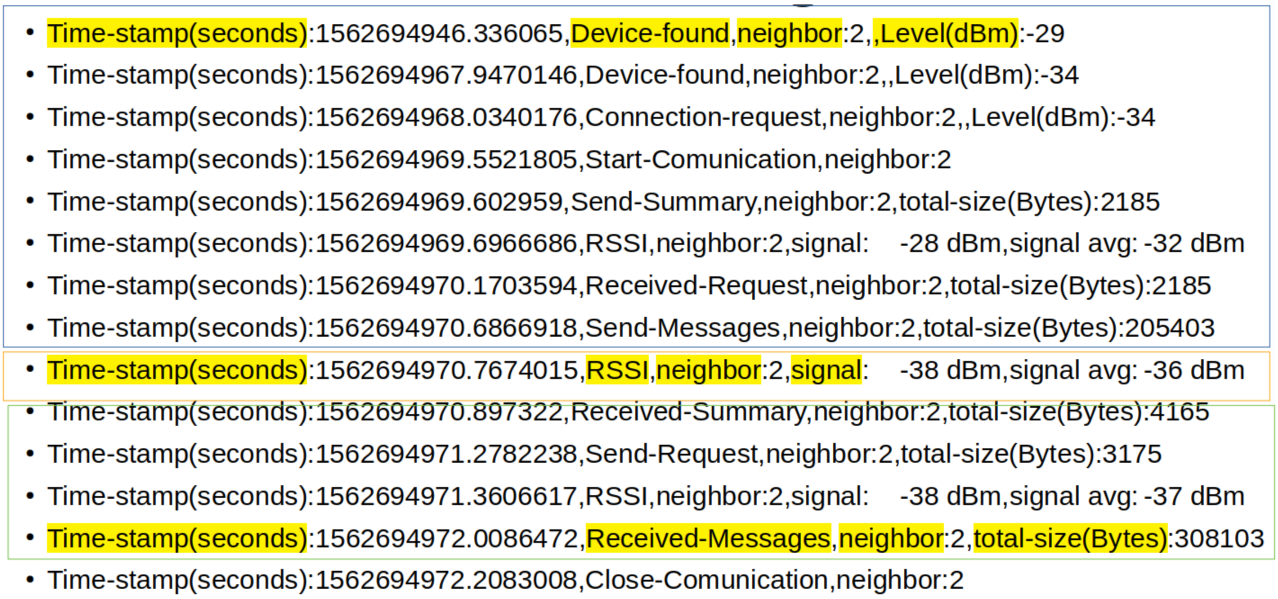
Communication cycle

```
952.622,Device-found,neighbor:2,dBm:-57            946.013,Device-found,neighbor:1,dBm:-42
961.241,Device-found,neighbor:2,dBm:-52            962.667,Device-found,neighbor:1,dBm:-30
967.947,Device-found,neighbor:2,dBm:-34
968.034,Connection-request,neighbor:2,dBm:-34      968.275,Connection-accept,neighbor:1,dBm:-26
969.552,Start-Comunication,neighbor:2              969.538,Start-Comunication,neighbor:1
969.602,Send-Summary,neighbor:2,Bytes:2185         969.665,Received-Summary,neighbor:1,Bytes:2185
970.170,Received-Request,neighbor:2,Bytes:2185     970.145,Send-Request,neighbor:1,Bytes:2185
970.686,Send-Messages,neighbor:2,Bytes:205403      970.737,Rec-Messages,neighbor:1,Bytes:205403
970.897,Received-Summary,neighbor:2,Bytes:4165     970.879,Send-Summary,neighbor:1,Bytes:4165
971.278,Send-Request,neighbor:2,Bytes:3175         971.266,Received-Request,neighbor:1,Bytes:3175
972.008,Rec-Messages,neighbor:2,Bytes:308103       971.838,Send-Messages,neighbor:1,Bytes:308103
972.108,Close-Comunication,neighbor:2              972.194,Close-Comunication,neighbor:1
975.235,Device-found,neighbor:2,dBm:-37            977.068,Device-found,neighbor:1,dBm:-30
```

2 More understandable log files

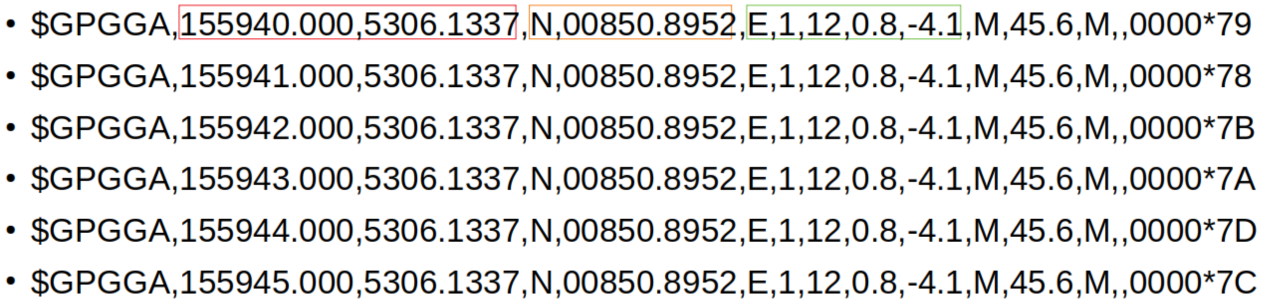
There are two log files, events.log and GNSS.log. The first file contains all the events related the communication protocol, and the second file contains the traces of the nodes.

The events are saved in a explicit way, which means that each parameter of the event is explained in the event itself as it is shown in the following figure.



```
• Time-stamp(seconds):1562694946.336065,Device-found,neighbor:2,,Level(dBm):-29
• Time-stamp(seconds):1562694967.9470146,Device-found,neighbor:2,,Level(dBm):-34
• Time-stamp(seconds):1562694968.0340176,Connection-request,neighbor:2,,Level(dBm):-34
• Time-stamp(seconds):1562694969.5521805,Start-Comunication,neighbor:2
• Time-stamp(seconds):1562694969.602959,Send-Summary,neighbor:2,total-size(Bytes):2185
• Time-stamp(seconds):1562694969.6966686,RSSI,neighbor:2,signal:    -28 dBm,signal avg: -32 dBm
• Time-stamp(seconds):1562694970.1703594,Received-Request,neighbor:2,total-size(Bytes):2185
• Time-stamp(seconds):1562694970.6866918,Send-Messages,neighbor:2,total-size(Bytes):205403
• Time-stamp(seconds):1562694970.7674015,RSSI,neighbor:2,signal:    -38 dBm,signal avg: -36 dBm
• Time-stamp(seconds):1562694970.897322,Received-Summary,neighbor:2,total-size(Bytes):4165
• Time-stamp(seconds):1562694971.2782238,Send-Request,neighbor:2,total-size(Bytes):3175
• Time-stamp(seconds):1562694971.3606617,RSSI,neighbor:2,signal:    -38 dBm,signal avg: -37 dBm
• Time-stamp(seconds):1562694972.0086472,Received-Messages,neighbor:2,total-size(Bytes):308103
• Time-stamp(seconds):1562694972.2083008,Close-Comunication,neighbor:2
```

Traces are saved in the format of NMEA codes as shown in the following figure .



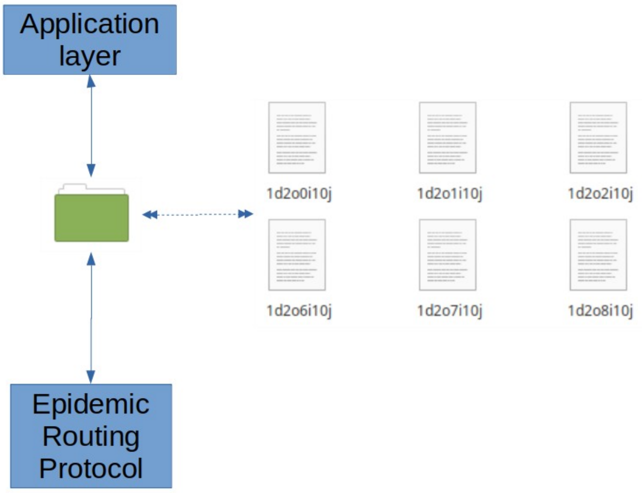
```
• $GPGGA,155940.000,5306.1337,N,00850.8952,E,1,12,0.8,-4.1,M,45.6,M,,0000*79
• $GPGGA,155941.000,5306.1337,N,00850.8952,E,1,12,0.8,-4.1,M,45.6,M,,0000*78
• $GPGGA,155942.000,5306.1337,N,00850.8952,E,1,12,0.8,-4.1,M,45.6,M,,0000*7B
• $GPGGA,155943.000,5306.1337,N,00850.8952,E,1,12,0.8,-4.1,M,45.6,M,,0000*7A
• $GPGGA,155944.000,5306.1337,N,00850.8952,E,1,12,0.8,-4.1,M,45.6,M,,0000*7D
• $GPGGA,155945.000,5306.1337,N,00850.8952,E,1,12,0.8,-4.1,M,45.6,M,,0000*7C
```

3 Extra parameters for experimental purposes

In order to add flexibility to the routing protocol, Three are new customizable parameters in the source file parameters.py.

4 Interface with application layer

The messages are files in the Linux file system. Therefore, it is possible to have an application layer than can be implemented independently from the routing protocol, as it is shown in the following figure.



Minor Enhancements

1 Hardware compatibility. The implementation is not attached to any specific hardware.

2 Updated source libraries. Updated programming language (from python 2.7 to python 3.3) and also updated the libraries used in the implementation.

3 Lock functions to protect sensitive operations. Block sensitive threats to avoid failures in the lof files and in the communication process.

4 Random Back off time implementation for WiFi direct connection. Avoid multiple connection requests at the same time.

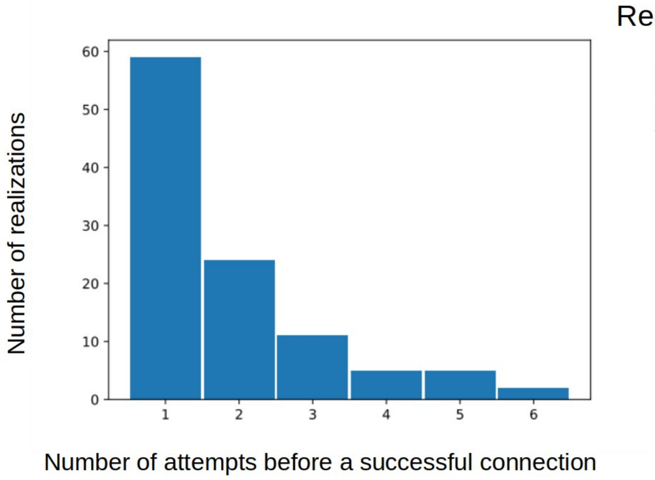
Results

Scenario

Two static nodes at a distance of 200 meters of each other, and a mobile node moving from one static node to another several times.

Metrics

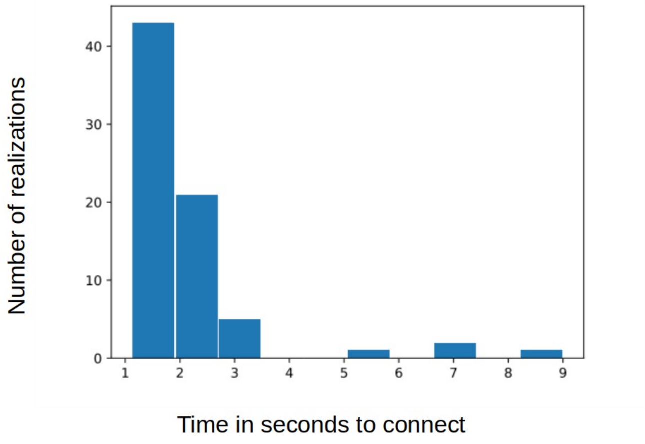
The following figures show the performance of the new implementation of the protocol



Realizations: 106

Mean: 1.858
Stdev: 1.247

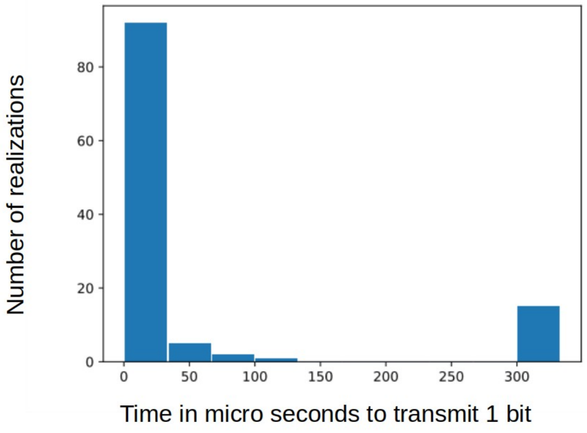
Min: 1
Max:6



Realizations: 73

Mean: 2.131s
Stdev: 1.29s

Min: 1.118s
Max:8.791s



Realizations: 115

Mean: 51.584us
Stdev: 100.965us

Min: 0.0501us
Max:324.223us

Conclusions

The current implementation failed to guaranty communication if two nodes are moving because the connection time is relative high. However, humans form groups in places like bus stops or classrooms, and communication is feasible in those environments.

Mobility models (like TRAILS, CMM, ORBIT), and Oportinistic network simulators (like OPNETS) are based in a binary assumption (in contact, or not in contact), but WiFi shows a different performance depending on the distance between two nodes. However, the current implementation addressed this problem by avoiding communication if the nodes are not at a distance where the quality of the depends very little of it.

WiFi direct and TCP/IP was not designed for MANET's applications. Therefore, a low level implementation may present results easier to interpret and easier to optimize.