Wireless Network Monitor App

We worked with the RF data collected using the Wireless Network Monitor App developed by Prof. Marco Di Felice, University of Bologna.
The App promises to collect and let us export from its database the following information:

LOCATION: GeoTagId, Longitude, Latitude
CELLINFO: CellName, Type (3G, 4G, W-CDMA), PowerLevel, Throughput, RTT
WIFIINFO: SSID, SecurityLevel, PowerLevel, Channel

The App is *event driven* i.e. either a change in location or a change in ambient radio environment triggers a data sample to be recorded. The App requires the GPS be turned on during the period of measurement. We noticed the App does not work inside a building or inside a Subway train as the GPS signal is quite poor.

The default GPS Setting is 50m (set as multiples of 10m) i.e. once the device moves 50m from the current location a new GPS sample is obtained promptly followed up with the RF data sample.

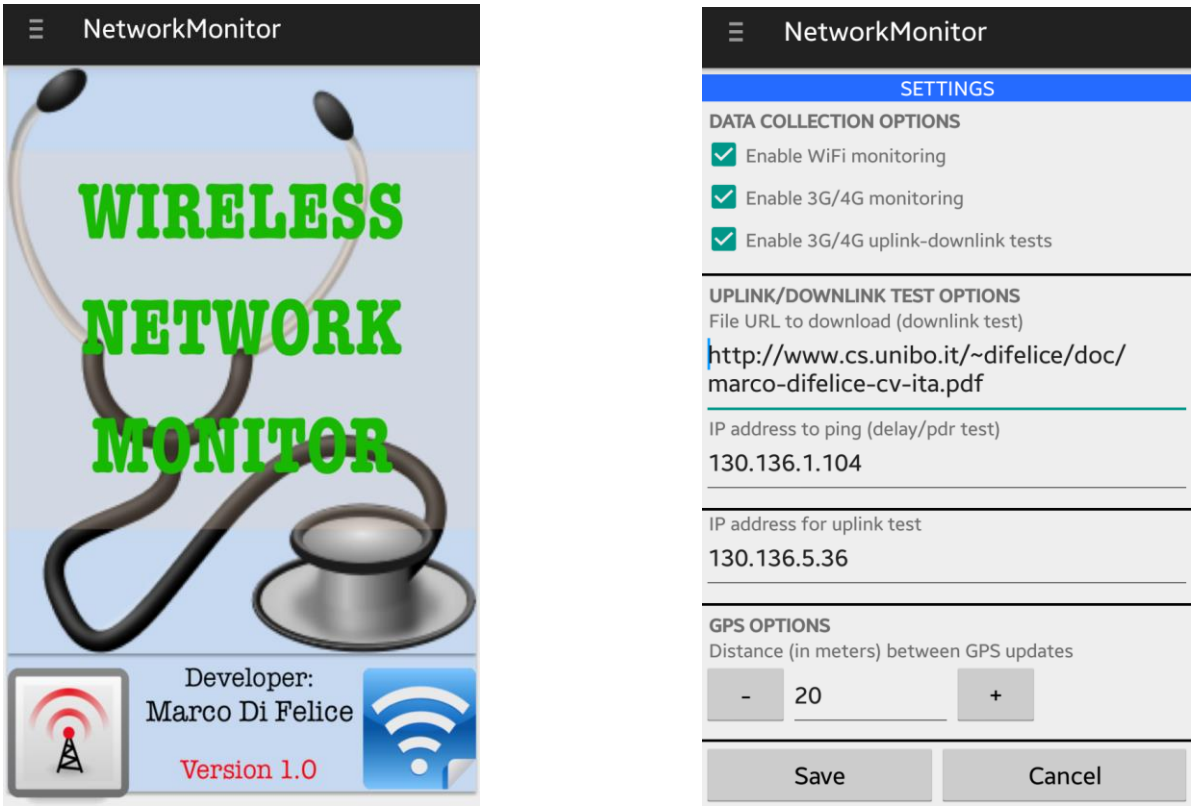

Figure 1: Screenshot of Wireless Network Monitor App | Home screen (left); Settings (right)

With the GPS turned on, the App keeps continuously sensing the channel, and upon pressing the 'Start Data Collection' button the App starts collecting the data; 'Stop Data Collection' stops collecting the data, and finally lets you export the data by pressing the 'Write to File' button. It is to be noted that the App reports an erroneous RSSI value of 0 when set to 0m - we ignore those RSSI entries when analyzing the data.

Here is a description of the features in the data recorded by the App:

1. **latitude** and **longitude** refers to the unique location of the mobile user with respect to the GPS.

2. **time** is a timestamp field, as returned by the GPS (hence, it is a composition of date+time, with a precision of seconds)

3. **speed** is the current velocity of users performing data collection. Again, it is returned by the GPS, and measured in m/s.

4. **type** refers to the type of network the mobile device is currently connected to. It is either 3G or 4G.

5. **rssi_avg and rssi_var** is the signal strength in 3G or 4G network.

6. **cellid** refers to the Cell Tower's ID obtained through the Downlink Scrambling Code: it's understood well, this code should be unique for each 3G/4G BTS. However, mapping the code (or the WiFi BSSID) to the position of the BTS/WiFi AP is altogether different process. For that, we might utilize triangulation techniques. Unfortunately, there isn't any map of the BTS positions for our current scenario (Bologna or Boston); this information is quite difficult to retrieve.

7. **cqi** (Channel Quality Indicator) is a single (integer value), reported by the Android system (not computed by us). It refers to the performance of the downlink system, considered as a whole (wideband CQI). It's a single value between 1-15, where 15 is the best. CQI determines the modulation scheme in use and the symbol efficiency.

http://www.sharetechnote.com/html/Handbook_LTE_CQI.html
(see Table 7.2.3-1)

8. **ssnr** is Signal Strength to Noise Ratio

9. **throughput_down** and **throughput_up** refers to the estimates of the downlink/uplink bandwidth computed post tests.

10. **delayCon** is the connection delay required to initiate a TCP connection with a remote host (again, IP address of the host can be configured)

11. **delay** refers to ping delay, i.e. RTT between the mobile device and another host (IP address can be configured from the Setting panel of the mobile app).

12. **pdr** refers to Packet Delivery Ratio, a measure of communication reliability, which is the fraction of packets that got delivered to packets that were sent out.

WiFi is turned on the smartphones when sensing. From the application GUI and setting panel, we can decide to enable/disable WiFi scanning.

Further, the App can collect information about the WiFI APs (position, SSID, BSSID, RSSI, frequency, securityProtocol, etc). But, they are not available as of now since the exported data has only the aggregate info. However, this data collection can be activated in the future version of the App.

In summary, the App collects for the 3G/4G signals:
1. **Latitude & Longitude**
2. **Time**
3. **Speed**
4. **Type**
5. **RSSI (average) & RSSI (variance)**
6. **CellID**
7. **CQI**
8. **SSNR**
9. **Bandwidth (downlink) & Bandwidth (uplink)**
10. **Connection Delay & Delay (delay_of_ping)**
11. **Packet Delivery Ratio**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	location	name	latitude	longitude	time	speed	type	rssi_avg	rssi_var	cellid	cqi	ssnr	throughput_down	throughput_up	delayCon	delay	pdr
2	9bus061915	lou	42.35012297	-71.07638447	1434723891400	6.9003844261	4G	-53	0	-1	2147483647	118	NA	NA	NA	NA	NA
3	9bus061915	lou	42.35020307	-71.07612825	1434723894000	6.9226078987	4G	-52	0	-1	2147483647	82	NA	NA	NA	NA	NA
4	9bus061915	lou	42.35029682	-71.07592067	1434723899000	5.0419440269	4G	-51	0	-1	2147483647	42	1.278673868	0	879	258	100
5	9bus061915	lou	42.3502322	-71.07565575	1434723906000	0.7111258507	4G	-50	0	-1	2147483647	38	1.169231576	0	320	258	100
6	9bus061915	lou	42.35028425	-71.07537832	1434723940000	4.0700001717	4G	-49	1.959184	-1	2147483647	-72	NA	NA	NA	NA	NA
7	9bus061915	lou	42.35047208	-71.07522614	1434723943000	6.1100001335	4G	-48	9	-1	2147483647	46	NA	NA	NA	NA	NA
8	9bus061915	lou	42.35062447	-71.07501048	1434723946000	7.5005397797	4G	-47	0	-1	2147483647	46	NA	NA	NA	NA	NA
9	9bus061915	lou	42.35070297	-71.07475789	1434723950000	5.8501367569	4G	-46	0	-1	2147483647	-24	1.6179921209	0	513	299	100
10	9bus061915	lou	42.35073564	-71.07448047	1434723955000	5.5401444435	4G	-45	0	-1	2147483647	12	NA	NA	NA	NA	NA

Figure 2: Snapshot of the App Data

When we analyzed our extensively collected data, we identified several issues with the updated app:

Major Issues:
1. Data entries corresponding to fields "ssnr", "cqi", "cellid" never change in the exported csv file. The 'cellid' and 'cqi' are always -1.
2. There are data fields in the data.. "throughput_up", "throughput_down", "delayCon", "delay_pdr" which are just recorded as NA.
3. We took measurements on a moving bus with GPS set to 20m and we noticed there are lots of zeros in the "rssi_avg" column entries. We're not sure this is being reported correctly.
4. We needed to install and use a third-party app to access the exported csv files. They appear hidden.

Minor Issues:
1. The App appears to export the csv files to phone's internal memory and not the external flash drive.
2. The column name corresponding to the "3G" entry does not exist. We have to sometimes manually enter a keyword 'type' in order to get the fields to align post exporting the csv files.
3. It would be useful if the current "elapsed time" be replaced with time stamp showing date and real-time.

These issues remain and are identical even when we test the app on a newer Samsung Galaxy S5 Android phone, Moto Nexus 6.