Evaluation of NB-IoT operating parameters

Laboratory Assignment

Assignment

The main goal of the laboratory is to learn about the NB-IoT networks, their real deployment, and their suitability for various use cases in terms of communication parameters. In the first task, students will learn how to obtain network quality parameters of the NB-IoT network. The second task focuses on how to connect the mobile terminal to the NB-IoT network and measure a qualitative parameter of the connection.

Measurement Instructions

Task 1 - NB-IoT Network Detection

In this task, students will try to detect NB-IoT cells (**Mobile Country Code** and **Mobile Network Code**) in the surrounding area, determine NB-IoT cells deployed for the laboratory session, and capture and decode signaling traffic. The next exciting task is the localization of eNodeB based on an acquired cell ID. The laboratory task utilizes the SDR USRP N210 device and the GNU radio software driver. Documentation for this exercise can be found at this link[1].

Detecting NB-IoT cells in the area

1. Open terminal and go to **`/home/gnuradio/srsRAN/build/lib/examples`**
   - ***cd /home/gnuradio/srsRAN/build/lib/examples***
2. Connect USRP N210 to PC
3. Run a NB-IoT cell search on band 20 (downlink frequency range 791-821 MHz).
   - ***`sudo ./cell_search_nbiot -b 20`***

Example of the output:

```
[298/299]: EARFCN 6448, 820.80 MHz looking for NPSS.

Found 1 cells
Found CELL 801.3 MHz, EARFCN=6253, PHYID=257, NPSS power=31.0 dBm
```

At the end of the search, you will get a list of cells from these cells and note all frequencies **<NB-IOT FREQUENCY>** of every cell.

Downlink signal transmission and analyzation

The transmission from the NB-IoT cell can be captured and analyzed. To do this, we need to run a script that will emulate a NB-IoT UE with RNTI 0x1234 and skip decoding SIB2 (since it is not transmitted by the NB-IoT cell).

[1] https://docs.srsran.com/en/next/app_notes/source/nbiot/source/index.html#transmit-and-receive-downlink-signal

1. In a terminal window go to **/home/gnuradio/srsRAN/build/lib/examples**
   - ***cd /home/gnuradio/srsRAN/build/lib/examples***
2. Run the NB-IoT UE with the frequency **<#NB-IOT FREQUENCY>** in **HERTZ** obtained from the previous task.
   - **sudo *./npdsch_ue -f* <NB-IOT FREQUENCY> *-r 0x1234 -s***
3. Based on found CELL-ID, locate the position of transmitting eNodeB and name of service provider.

When the process is running the UE will start collecting Master Information Blocks (MIB) and System Information Blocks (SIB), as shown in the following example:

```
Set RX freq: 820.000000 MHz
Setting sampling rate 1.92 MHz
NSSS with peak=24.363365, cell-id: 0, partial SFN: 0
*Found n_id_ncell:   0 DetectRatio= 0% PSR=8.66, Power=86.4 dBm
MIB received (CFO:  -1,55 kHz) FrameCnt: 0, State: 10
SIB1 received
CFO:  -1,41 kHz, RSRP: 12,0 dBm SNR: 19,0 dB, RSRQ: -3,7 dB, NPDCCH detected: 510, NPDSCH-
BLER:  0,20% (1 of total 511), NPDSCH-Rate: 10,36 kbit/s
```

Task 2 – Connect to the NB-IoT network and verify the connection

The main goal of this task is to connect the NB-IoT device to the mobile network and verify the connection. The NB-IoT terminal is an IoT device Ublox EVK-N2xx with the SARA-N2 chipset. Much information about the used hardware is in manuals. The modem has an AT command interpreter for control and management see Error! Reference source not found..

Figure 1. NB-IoT network measuring device based on Ublox EVK-N2xx development kit with SARA-N2 chip.

Connect modem to the NB-IoT network and observe connection parameters

1. Configure modem by AT commands.
2. Based on available NB-IoT providers (T-Mobile, Vodafone), connect to the network
3. Measure a round trip time between the NB-IoT terminal and specified IP address
4. Acquire signal parameters (RSRQ, RSRP etc.) from the actual connection.
5. Based on acquired cell ID localize eNodeB position (use gsmweb.cz).

Appendix I

Ublox EVK-N2xx cheat box

AT commands

- Serial line parameters: 9600 8N1
- Receive: CR+LF
- Transmit: CR+LF
- AT Commands Manual: ***SARA-N2_ATCommands_(UBX-16014887).pdf***

Modem control commands

```
01.     at+cops=2       # Disconnect modem from network
02.     at+cfun=0       # switch off RF interface
03.     at+nrb          # modem restart
```

Check signal status

```
01.     at+nuestats="ALL"
```

Check RTT

```
01.     at+nping="147.32.211.2",100,5000
```

Connection diagnostic commands

```
01.     at+cscon=1      # connection status
02.     at+cereg=1      # network registration status
03.     at+npsmr=1      # powersave mode status
```

Connect modem to the Vodafone network

```
01.     at+cfun=1
02.     at+cgdcont=0,"IP","lpwa.vodafone.com"
03.     at+cops=1,2,"23003"
```

Connect modem to the T-Mobile network

```
01.     at+cfun=1
02.     at+cgdcont=0,"IP","iot.t-mobile.cz"
03.     at+cops=1,2,"23001"
```

Home Preparation

As part of home preparation, qualitative research data can be obtained by analyzing /measuring NB-IoT networks from relevant materials. Please pay particular attention to those parameters that could be used to analyze the network itself and answer individual questions. A typical evaluation example is elaborated within the theoretical part of this laboratory task. In addition, explore the possibilities of locating base stations in the Czech Republic and worldwide for mobile services and find out what parameters most often lead to identifying a cell/base station. Czech websites for this purpose include e.g., www.gsmweb.cz[2], making it easier to locate the NB-IoT cell you are looking for. Keep in mind that unique cell identifiers usually have the same base of letters or numbers that characterize the entire base station, so if you cannot find an NB-IoT cell directly, you are more likely to find the same base station but cells with technologies like 2G/3G/4G/5G.

Task: NB-IoT modem is connected to the eNodB. The signal log is in Tab. 1. Please find the place covered by mentioned eNodB.

UTC ISO time	UTC timestamp	Signal power	Total power	TX power	TX time	RX time	Cell ID	ECL	SNR	EARFCN	PCI	RSRQ	RLC UL BLER	RLC DL BLER	MAC UL BLER	MAC DL BLER	Total TX bytes	Total RX bytes	Total TX blocks	Total RX blocks	Total RTX blocks	Total ACK/NACK RX	RLC UL	RLC DL	MAC UL	MAC DL	Current Allocated	Total Free	Max Free	Num Allocs	Num Frees	CELL earfcn	CELL physical_cell_id	CELL primary_cell	CELL rsrp	CELL rsrq	CELL rssi	CELL snr
Tue Nov 19 11:43:03 2019	1574163783	-764	-693	-8	368	68429	36982188	0	93	6247	207	-110	0	0	0	0	309	428	13	12	0	0	2068	400	6112	5176	1606	6900	6900	65	1	6247	207	1	-76.4	-11	-69.3	9.3
Tue Nov 19 11:43:38 2019	1574163818	-772	-699	-6	11228	87513	36982188	0	89	6247	207	-111	0	0	0	7	18418	19331	214	263	0	0	8819	15310	15488	16923	1606	6900	6900	173	109	6247	207	1	-76.8	-10.8	-69.9	10.8
Tue Nov 19 11:45:01 2019	1574163901	-766	-696	-6	11277	106791	36982188	0	95	6247	207	-110	0	0	0	7	18429	19357	215	264	0	0	8819	235	15488	3924	1606	6900	6900	177	113	6247	207	1	-76.6	-11	-69.6	9.5
Tue Nov 19 11:45:36 2019	1574163936	-770	-699	-7	22189	125679	36982188	0	90	6247	207	-111	0	0	0	3	36585	38260	419	515	0	0	9962	18955	15531	16923	1606	6900	6900	285	221	6247	207	1	-76.7	-10.8	-69.9	10.4

Tab. 1: Output of the command: at+nuestats="ALL".

[2] https://www.gsmweb.cz/