Use of Mobile Network Analytics for Application Performance Design

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MNM’17 Dublin – June 2017

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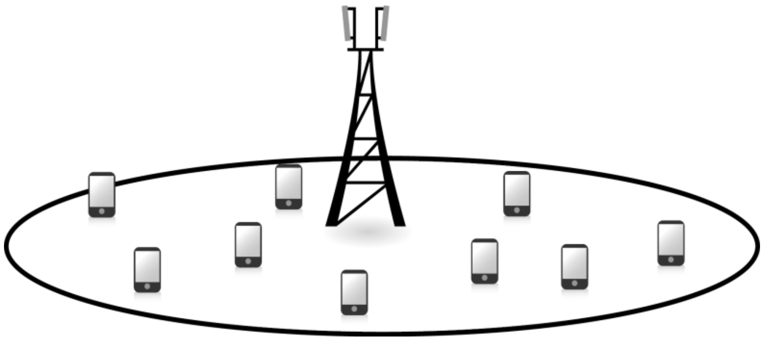
Summary

- Introduction
- NApplytics description
- Results and discussions
- Conclusions
- Future work

Introduction

- The **5G** will lead to an increase of:
  - The data traffic.
  - The number of connected devices.



- The **mobile phones** will be cornerstones in our daily live
  - It is critical to understand the mobile network performance, to:
    - Provide a superior user experience.
    - Determine the success of an application (APP).

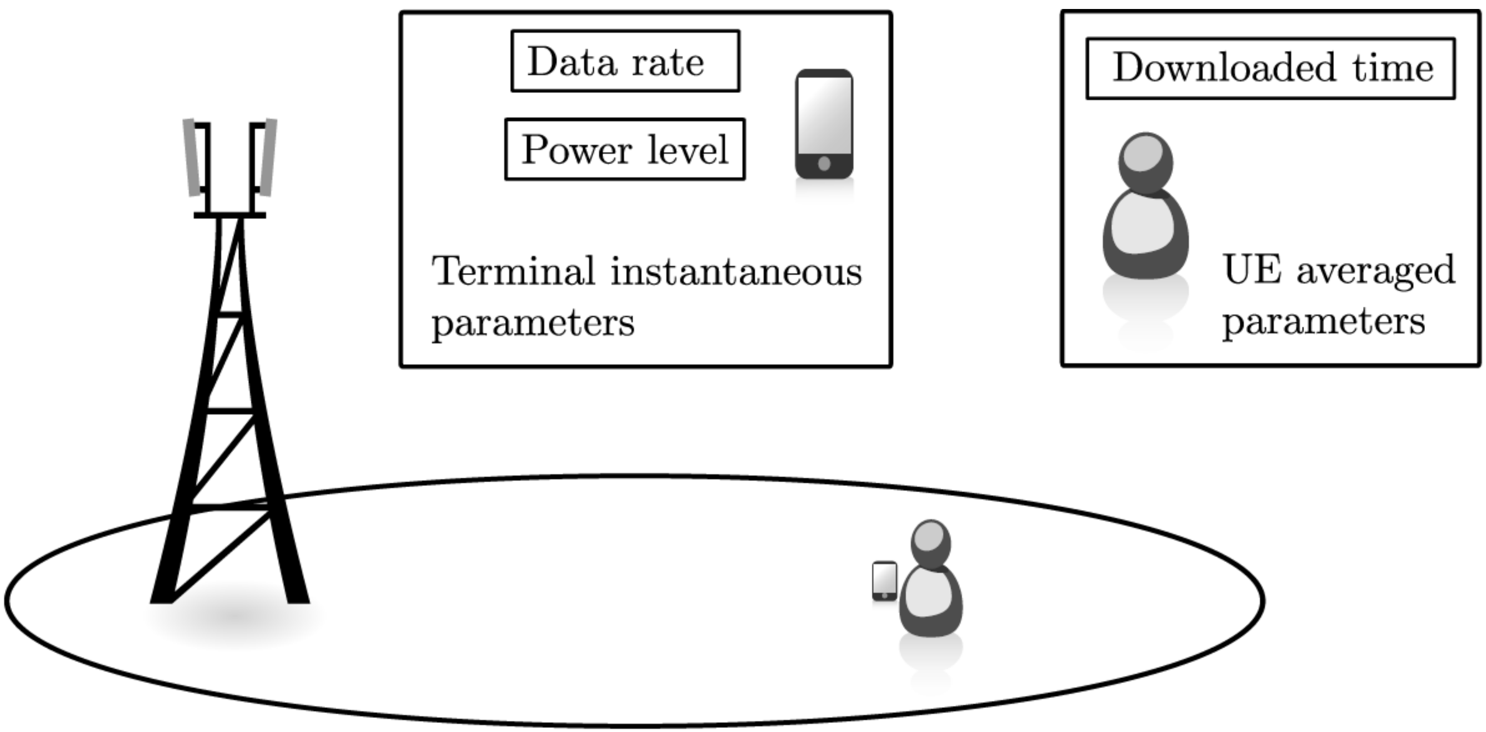
Introduction

- This **study:**
  - Is part of the MONROE Project.
  - Is done under the collaboration of:

  - We present a solution that uses the radio parameters measured by a mobile terminal to determine the best Application Protocol (APPP) for a service.

Introduction

- Motivation:
  - Necessity to correlate instantaneous parameters measured by the terminal with averaged parameters perceived by the user.



NApplytics description

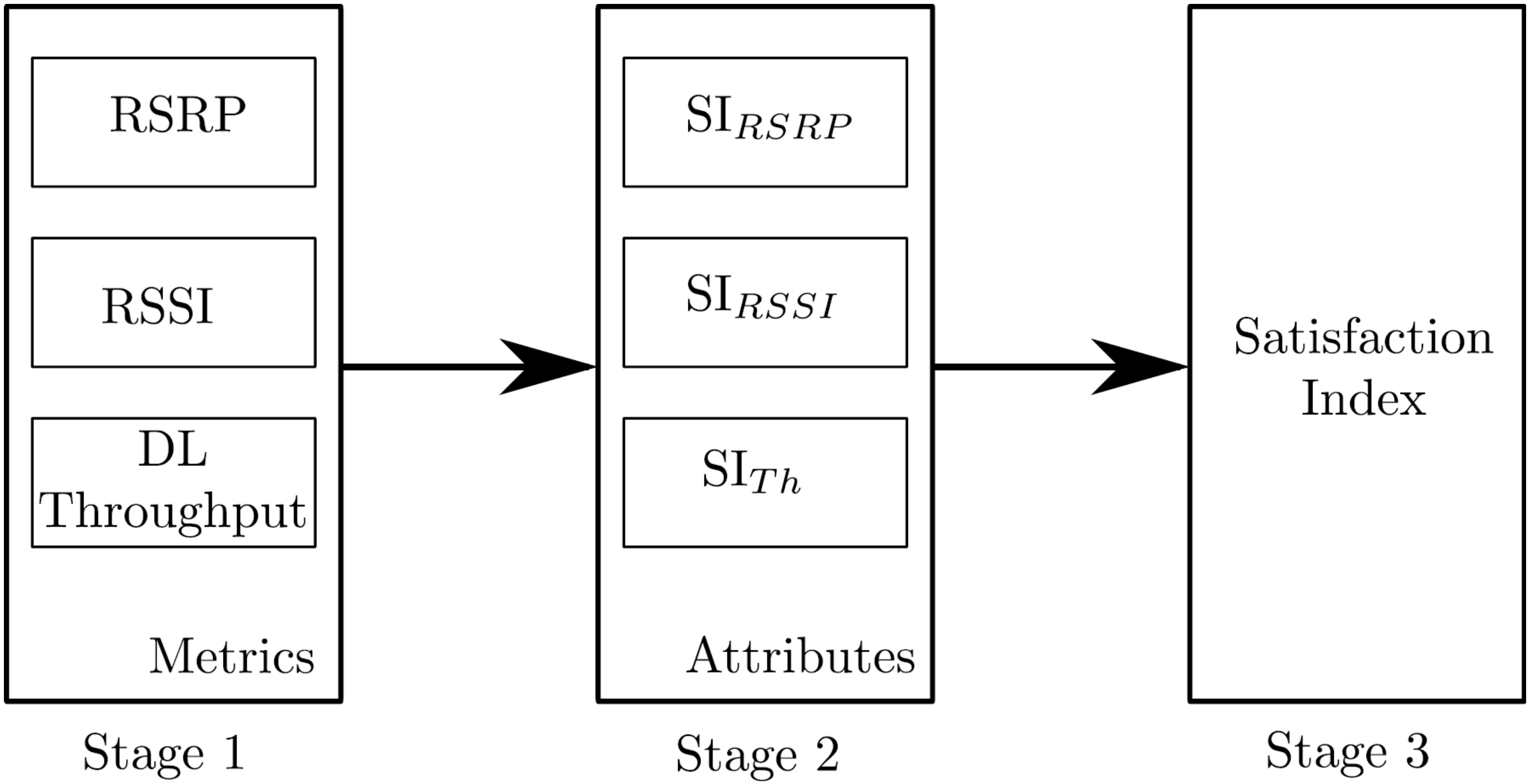
- NApplytics is **designed** to:
  - Be an Android library.
  - Select the most appropriated APPP depending on the network conditions experienced by the user.
  - Be transparent for both: APP users and APP developers.

NApplytics description

- So, we need models to capture the relationship between the QoS and the QoE.
- We present a customer **Satisfaction Index (SI)** that:
  - Provides the actual customer perception (QoE).
  - Identifies the most appropriated APPP.
- This study focuses on three APPP:
  - HTTP1.1
  - HTTP2
  - HTTP1.1 TLS
- We give only details for the Long Term Evolution (LTE) technology.

NApplytics description

- **SI** procedure:



NApplytics description

- **SI** procedure:
  1. Metrics definition
     - The networks metrics used are:
       - Reference Signal Received Power (RSRP)
       - Received Signal Strength Indicator (RSSI)
       - Downlink Throughput (Th)
  2. Attributes calculation
     - Each attribute has five levels of quality:

Score	User experience quality
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

NApplytics description

- **SI** procedure:
  1. Metrics definition
  2. Attributes calculation
     - The attribute for the RSRP metric in dBm is:

$$SI_{RSRP} = \begin{cases} 1, & for\ RSRP \leq -109 \\ f_1^{RSRP}, & for\ RSRP\ \in\ ]-109, -103] \\ f_2^{RSRP}, & for\ RSRP\ \in\ ]-103, -97] \\ f_3^{RSRP}, & for\ RSRP\ \in\ ]-97, -92] \\ f_4^{RSRP}, & for\ RSRP\ \in\ ]-92, -88] \\ 5, & for\ RSRP > -88 \end{cases}$$

Experimental results

where f_X^{RSRP} are linear functions inside each interval. For example:

$$f_1^{RSRP} = 1 + \frac{RSRP + 109}{6}$$

NApplytics description

- **SI** procedure:
  1. Metrics definition
  2. Attributes calculation
  3. SI calculation
     - SI is defined as:

$$SI = w_1 SI_{RSRP} + w_2 SI_{RSSI} + w_3 SI_{Th}$$

     - We measure the QoE by means of utility functions. For the web browsing service the utility function (U) is defined by [1]:

$$U = 5 - \frac{578}{1 + \left(11.77 + \frac{22.61}{d}\right)^2}$$

where d is the service respond time measured in seconds.

[1] P. Ameigeiras, J. J. Ramos-Munoz, J. Navarro-Ortiz, and P. Monensen. QoE Oriented Cross-layer Design of a Resource Allocation Algorithm in Beyond 3G Systems, Computer Communications, 33(5), 571-582, 2010.

NApplytics description

- **SI** procedure:
  1. Metrics definition
  2. Attributes calculation
  3. SI calculation
     - The weights are calculated by minimizing the Mean Square Error (MSE):

$$\min_{w_1,w_2,w_3} \overline{(U - SI)^2}$$

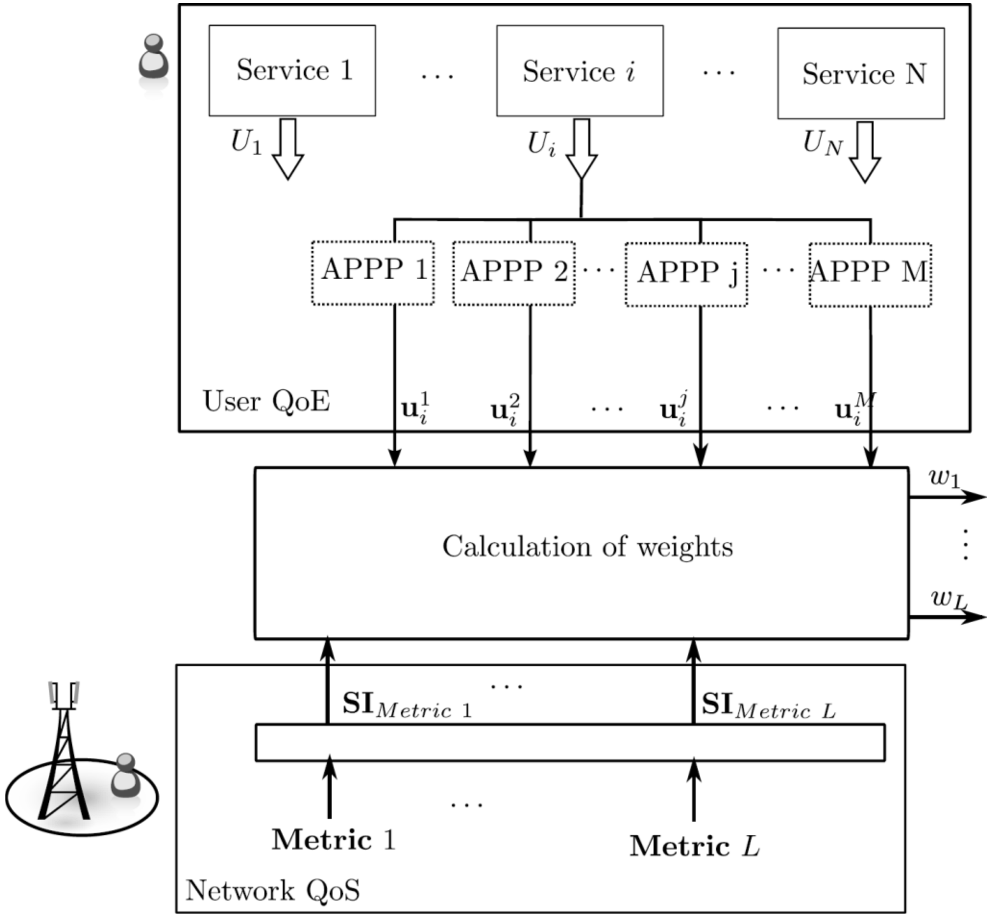
     - This process will be executed for each APPPs.

- NApplytics selects the APPP in execution time that fits:

$$\max\left[SI_{APPP_1},\ SI_{APPP_2}, \dots,\ SI_{APPP_M}\right]$$

NApplytics description

- Overall calculation of the different SI in the training phase:

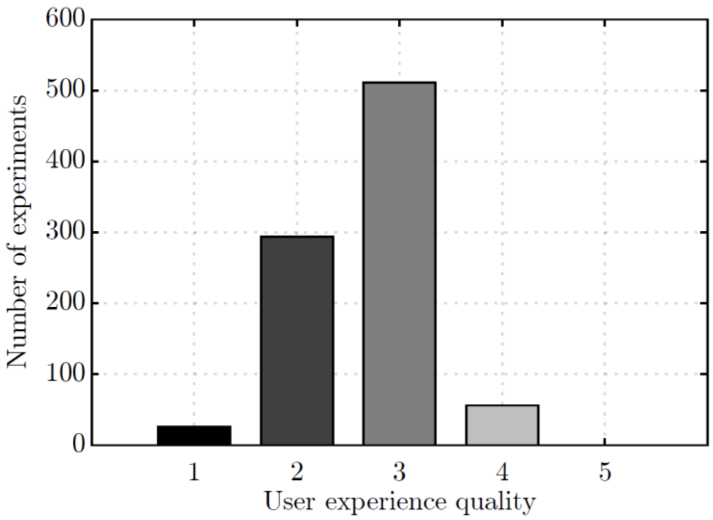


Results and discussions

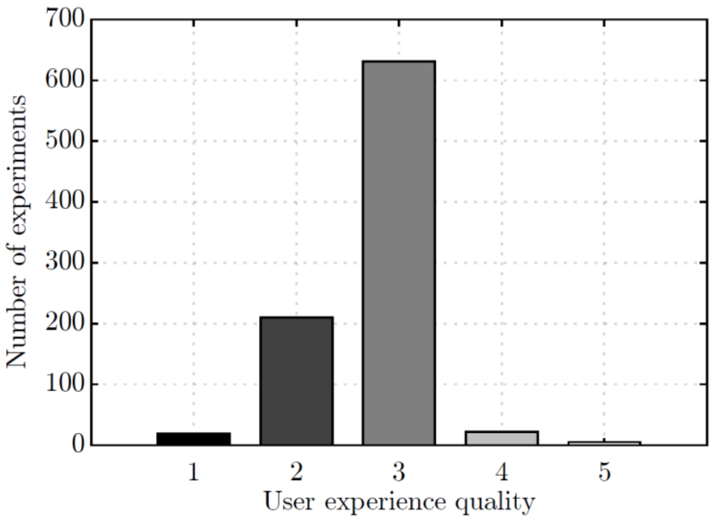
- Service analyzed: web browsing
- Protocols: HTTP1.1, HTTP2 and HTTP1.1 TLS
- Experiments realized:
  - More than 2500 experiments
  - Combination of headlessbrowsing and http_download

Results and discussions: HTTP1.1 Protocol

- 887 experiments done
- **Distribution of the user experience quality:**



Distribution by the SI



Distribution by the U

Results and discussions

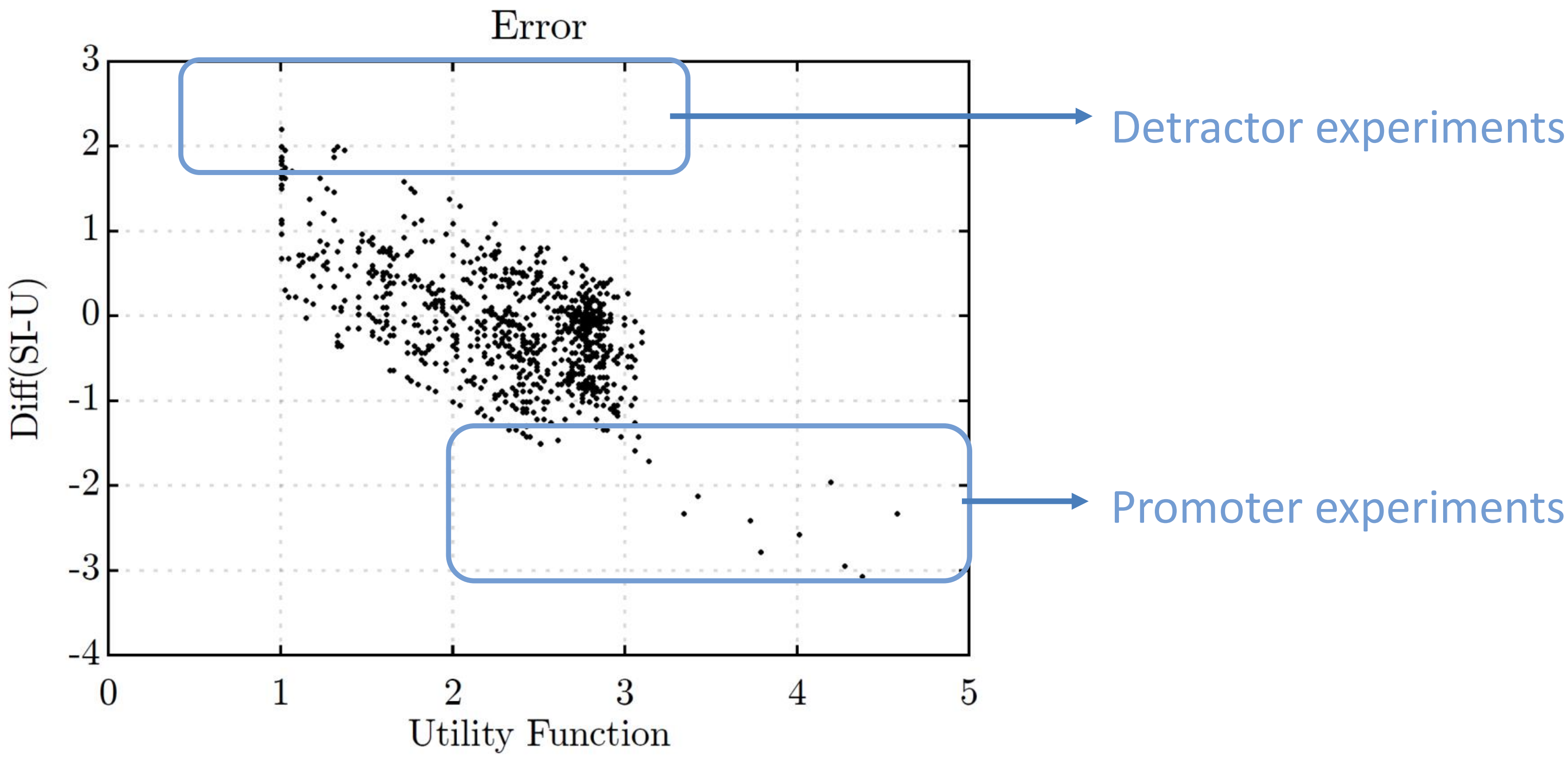
- **Detractor experiments** are those who fulfill that:

$$SI - U \geq 1.5$$

- In contrast, **promoter experiments** are those who fulfill that:

$$SI - U \leq -1.5$$

Results and discussions



Results and discussions

- Weight percentage of each parameter:

Parameter	HTTP1.1	HTTP2	HTTP1.1 TLS
RSRP	30.77%	33.04%	32.57%
RSSI	28.05%	28.06%	27.8%
DL Throughput	41.19%	38.9%	39.63%

- Percentage of detractors and promoters:

Protocol	Detractors	Promoters
HTTP1.1	3.04%	1.47%
HTTP2	1.32%	1.59%
HTTP1.1 TLS	1.8%	1.94%

Results and discussions

- Correlation with and without detractors and promotes experiments:

Protocol	Correlation	Correlation without D&P
HTTP1.1	86.58%	90.67%
HTTP2	86.9%	89.51%
HTTP1.1 TLS	83.72%	86.98%

- Mean Square Error:

Protocol	MSE
HTTP1.1	0.5
HTTP2	0.53
HTTP1.1 TLS	0.59

Conclusions

- A **new approach** to correlate network KPIs with user experience while using an APP is designed.
- This will help software APP developers to understand the user's experience during the APP execution and act accordingly (e.g. changing the APPP).
- We obtain a high correlation for the web browsing service.

Future work

- Implement more services:
  - Video streaming (e.g. YouTube)
  - Voice over IP
  - …
- Implement more protocols:
  - RTP
  - UDP
  - …

Thank you for your attention!

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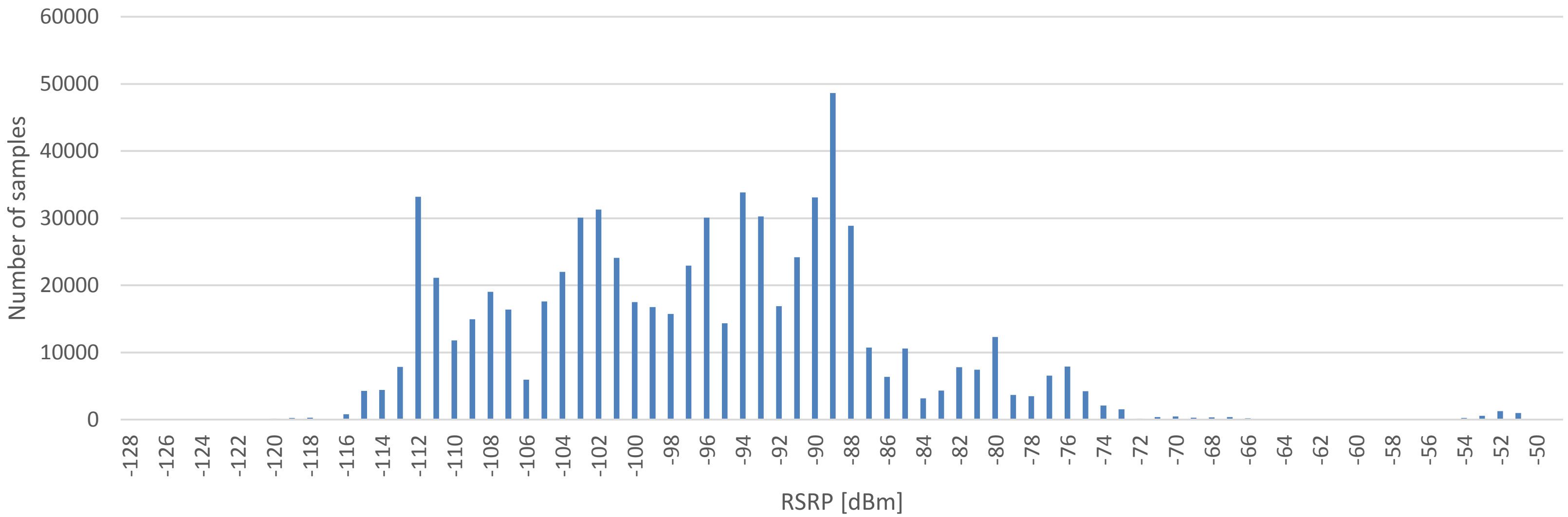
NApplytics description

- Distribution accordingly to RSRP values:



- Each level has been chosen with the aim of having a similar number of samples.
- 696,111 samples from MONROE database.

SI Level	RSRP Range	# Samples
1	≤ −109	99,217
1-2	]−109, −103]	111,028
2-3	]−103, −97]	128,332
3-4	]−97, −92]	125,451
4-5	]−92, −88]	134,775
5	> −88	97,308

NApplytics description

- For the training phase the same type of experiments that for the testing phase has been realized.

- The weights are calculated by minimizing the Mean Square Error (MSE):

$$\min_{w_1, w_2, w_3} \overline{(U - SI)^2}$$

- This problem was solved using the Generalized Reduce Gradient (GRG):
  - Is a generalization of the reduced gradient method by allowing nonlinear constraints and arbitrary bounds on the variables.

NApplytics metrics

- We considered to use the following metrics:
  - RSRP (Reference Signal Receive Power)
  - RSRQ (Reference Signal Receive Quality)
  - RSSI (Received Signal Strength Indicator)
  - Downlink Throughput
- But RSRQ depends on RSRP and RSSI:

$$RSRQ = (N\_RB * RSRP) / RSSI$$

, being N_RB the number of resource blocks.

- In case there is no noise and no interferences:

$$RSSI = 12 * N * RSRP$$