



# Use of Mobile Network Analytics for Application Performance Design

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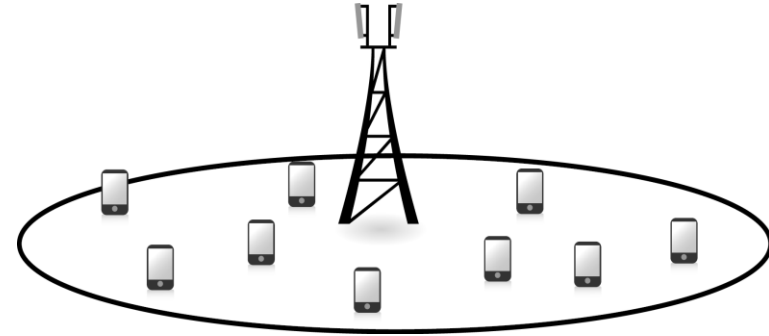


- Introduction
- NApplytics description
- Results and discussions
- Conclusions
- Future work





- 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).



- This **study**:

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

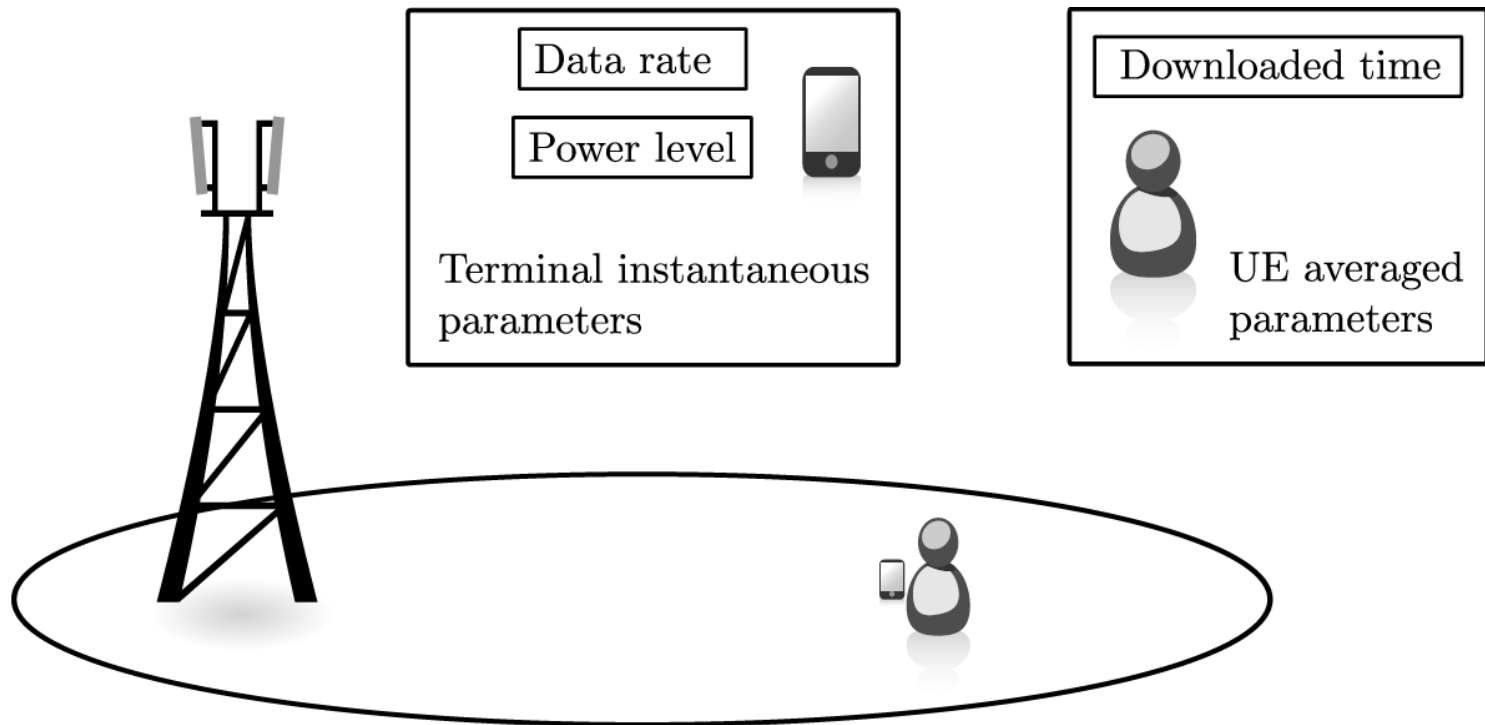


- We present a solution that uses the radio parameters measured by a mobile terminal to determine the best Application Protocol (APPP) for a service.



- Motivation:

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





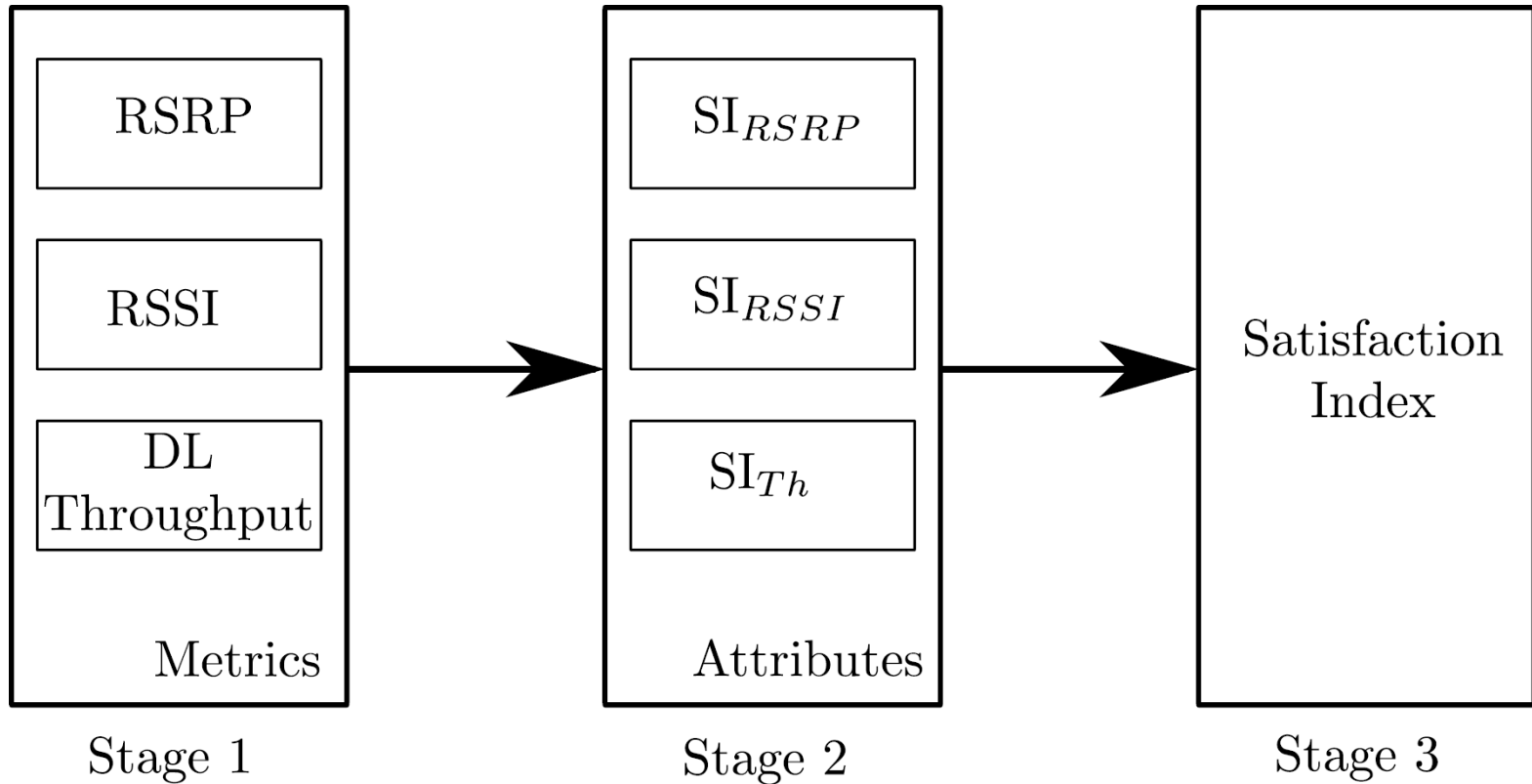
- NApplytics is **designed** to:
  - Be an Android library.
  - Select the most appropriated APPP depending on the network conditions experienced by the user.
  - Be transparent for both: APP users and APP developers.



- 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.



- **SI** procedure:







- **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



- **SI** procedure:

1. Metrics definition

2. Attributes calculation

- The attribute for the RSRP metric in dBm is:

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

Experimental results

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

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



- **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.



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

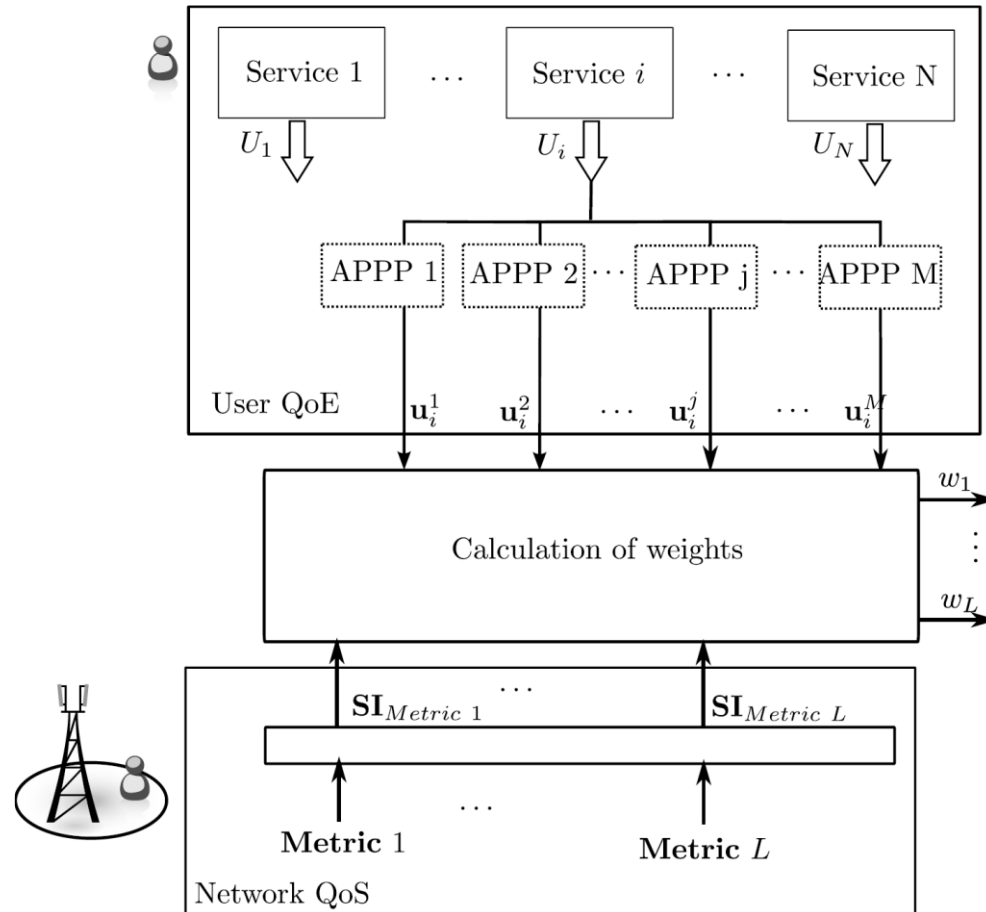
$$\min_{w_1, w_2, w_3} \overline{(U - SI)^2}$$

- This process will be executed for each APPPs.
- NApplytics selects the APPP in execution time that fits:

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



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

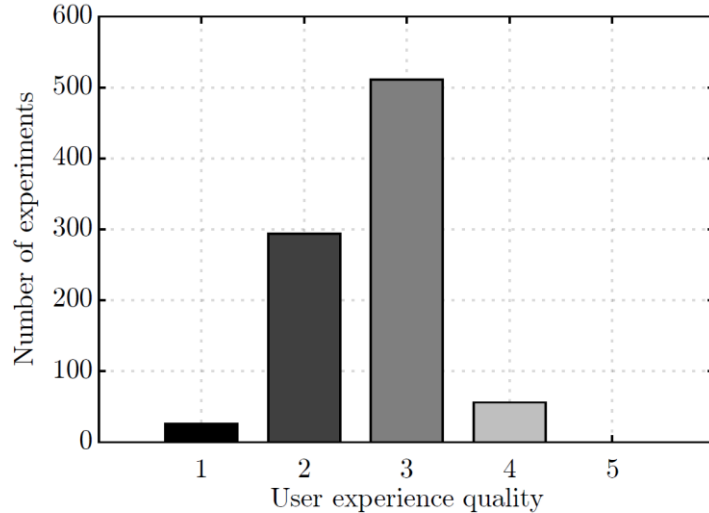




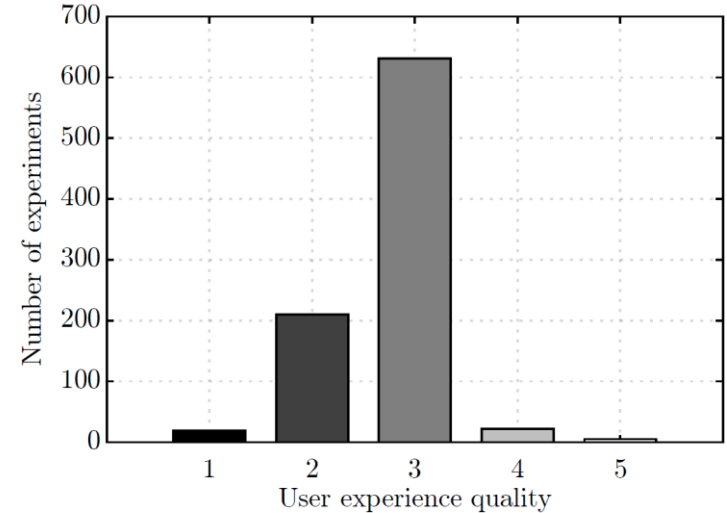
- Service analyzed: [web browsing](#)
- Protocols: [HTTP1.1](#), [HTTP2](#) and [HTTP1.1 TLS](#)
- Experiments realized:
  - More than 2500 experiments
  - Combination of `headlessbrowsing` and `http_download`



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



Distribution by the SI



Distribution by the U



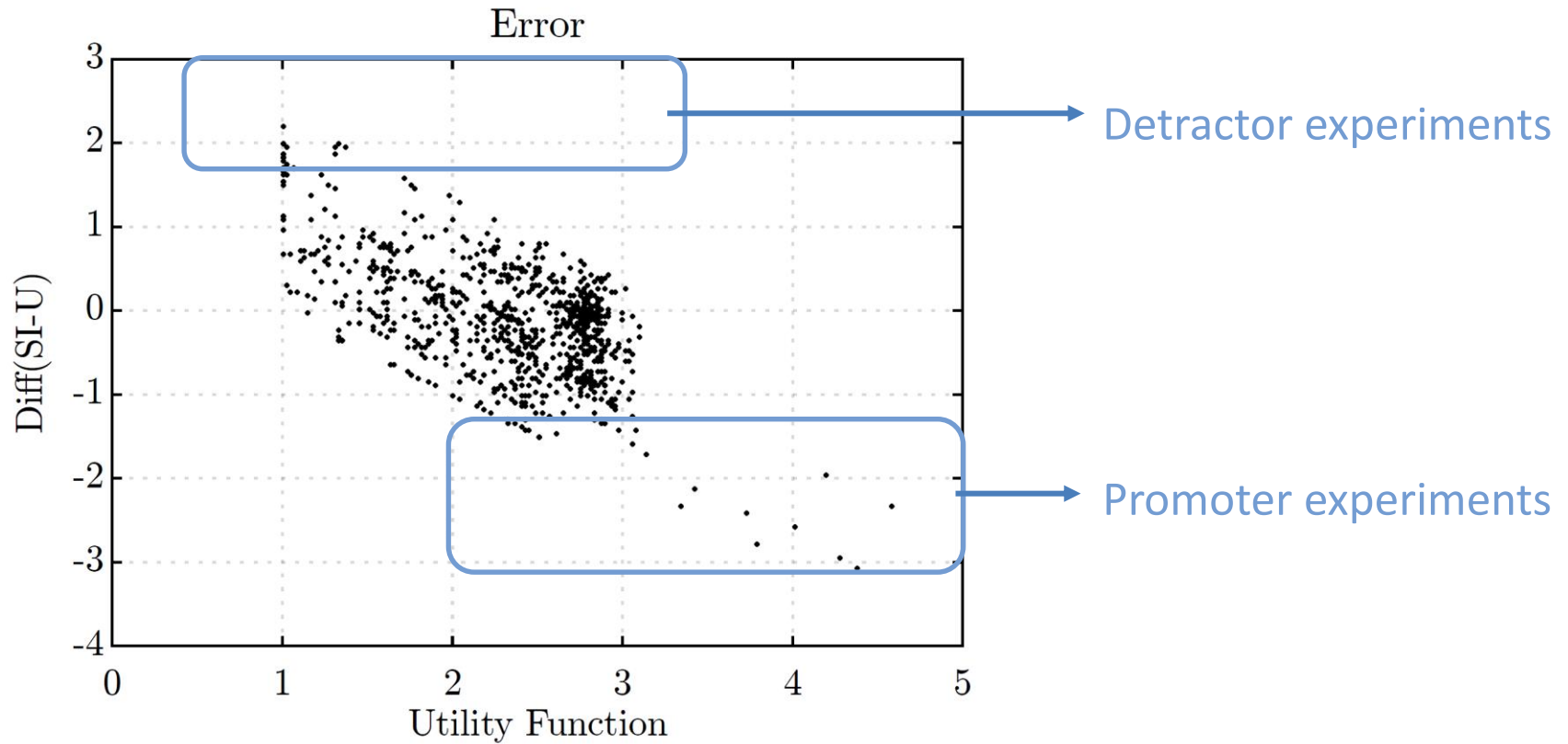
- **Detractor experiments** are those who fulfill that:

$$SI - U \geq 1.5$$

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

$$SI - U \leq -1.5$$







- 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%



- 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



- 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 APP).
- We obtain a **high correlation** for the web browsing service.



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



**Thank you for your attention!**

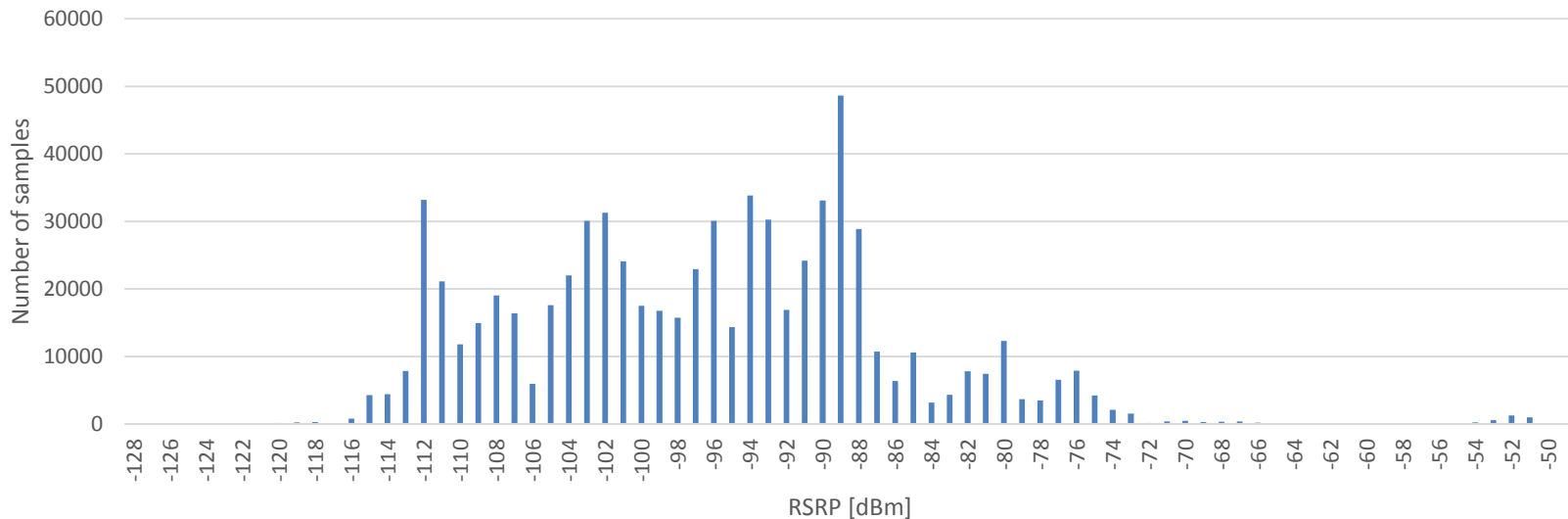
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- Distribution accordingly to RSRP values:



- 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	$\leq -109$	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



- 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.





- 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:

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

, being N\_RB the number of resource blocks.

- In case there is no noise and no interferences:

$$\text{RSSI} = 12 * \text{N} * \text{RSRP}$$