

## Wi-Fi Score

Goal: Create a Wi-Fi Score which is able to capture customer's Wi-Fi experience score

Customer's Perspective: From a customer standpoint Wi-Fi experience can be categorized as

1. Coverage
2. Speed
3. Reliability/Stability

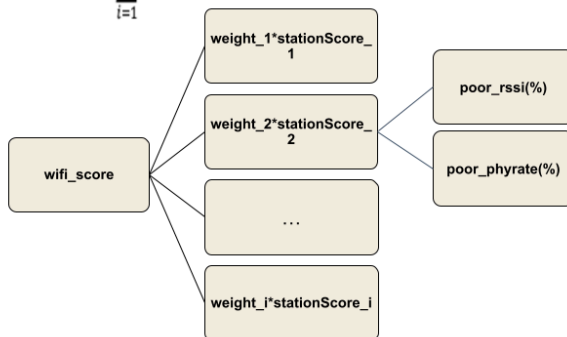
Keeping in mind the above Wi-Fi score should be able to measure these 3 components of Wi-Fi to align with customer's experience.

Converting our current WiFi score to Coverage/Speed/Reliability below is how it would look like

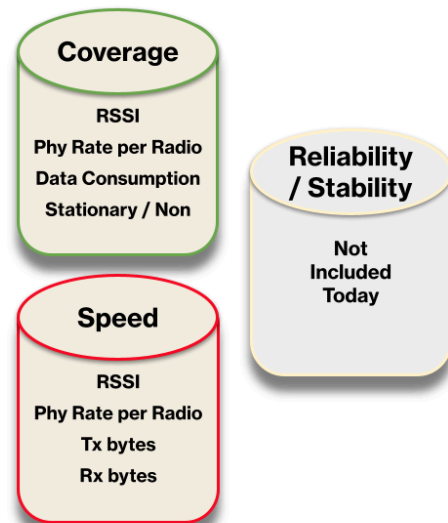
### Today : Wi-Fi Score

$$stationScore_i = weight_{rssi} \times (1 - \%poor_{rssi}) + weight_{phyrate} \times (1 - \%poor_{phyrate})$$

$$wifiScore = \sum_{i=1}^n station\_weight_i \times stationScore_i$$



*Note: Weights based on Data Consumption & Mobility*



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Fig 1: WiFi score mapping to customer experience components

With newer version of Wi-Fi score goal is to use additional KPIs to track components around coverage/speed/stability more accurately

Table with new KPI's for improved Wi-Fi Score

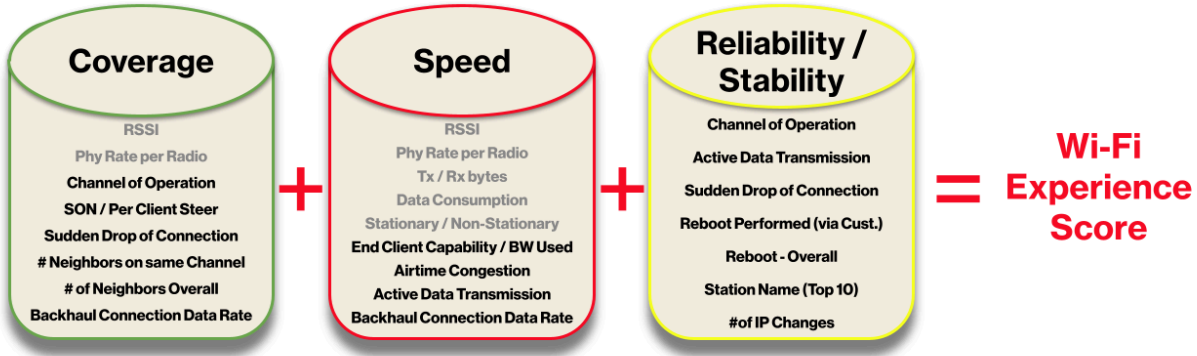
|    | Feature Name   |
|----|--|
| 1  | RSSI   |
| 2  | Phy rate per radio   |
| 3  | Tx bytes   |
| 4  | Rx bytes   |
| 5  | Data consumption   |
| 6  | Stationary/Non-Stationary  |
| 7  | End client capability / Bandwidth used - mode                            |
| 8  | Airtime congestion   |
| 9  | Channel of operation   |
| 10 | SON/Per client steer   |
| 11 | Active data transmission - phy rate                                      |
| 12 | Sudden drop of connection - more than 3 clients (stationary) disappeared |
| 13 | Reboot performed via customer  |
| 14 | Overall reboot   |
| 15 | station name ( iphone, Macbook, Galaxy, ipad -- top 10 devices)          |
| 16 | # of neighbors on same channel (channel scan)                            |
| 17 | # of overall neighbors (other channels combined)                         |
| 18 | # of neighbors on adjacent channel (channel scan)                        |
| 19 | # of ip changes  |
| 20 | SON OFF  |
| 21 | Extender backhaul range  |
| 22 | Ethernet and not 1 Gig   |

Table 1.1 Feature set for new WiFi Score

Converting above KPI's to Wi-Fi Experience

## Tomorrow (EOM Sept) : Wi-Fi Experience Score

- 13 Additional KPI's
- 3 point scale



Coverage + Speed + Reliability = Max Score of 3

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One of the criteria of WiFi Score is it should equally weight 3 pillars to come up with one final score

For example, an Ideal Home has

1. Coverage - score 1 (or 33.33)
2. Speed - score 1 (or 33.33)
3. Reliability - score 1 (or 33.33)

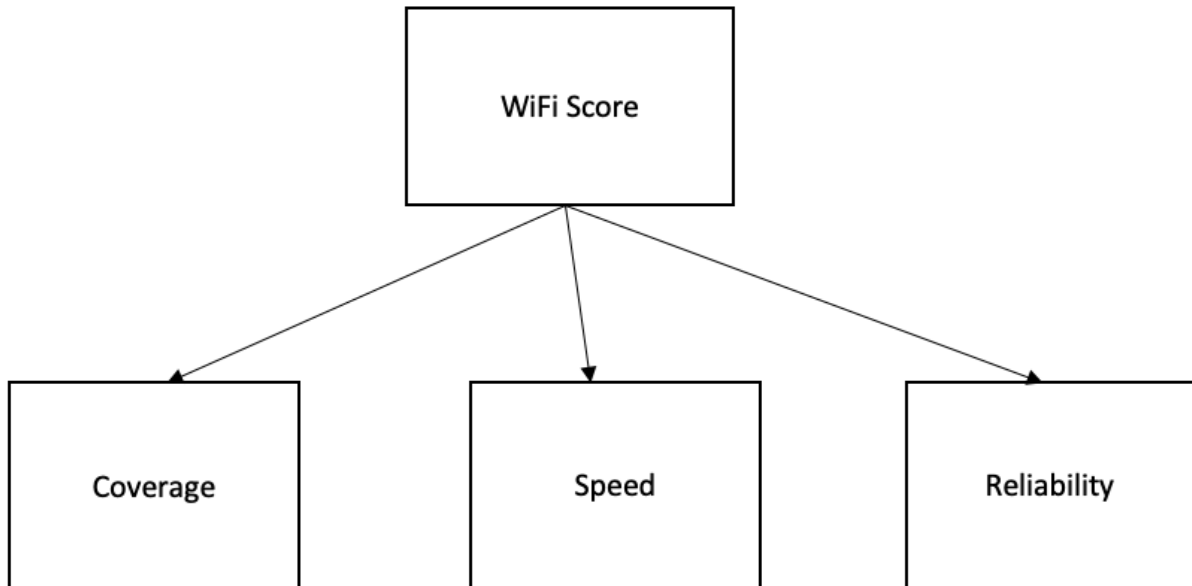
Resulting in a max score of 3 (or 100) for a given home. So any home from field which has for reference has Wi-Fi score of 80 on scale of 100 requirement is ability to break down that home's score into below

Example: Overall Wi-Fi Score 80

1. Coverage: 25/33.33 (75%)
2. Speed: 25/33.33 (75%)
3. Reliability: 30/33.33 (90%)

## Section 2: High Level Framework for Business Logic

In order to achieve a Wi-Fi score which tracks customer's experience accurately we need a modular framework where each KPI and its associated weight can be changed on runtime to map with field test results and adapt around it

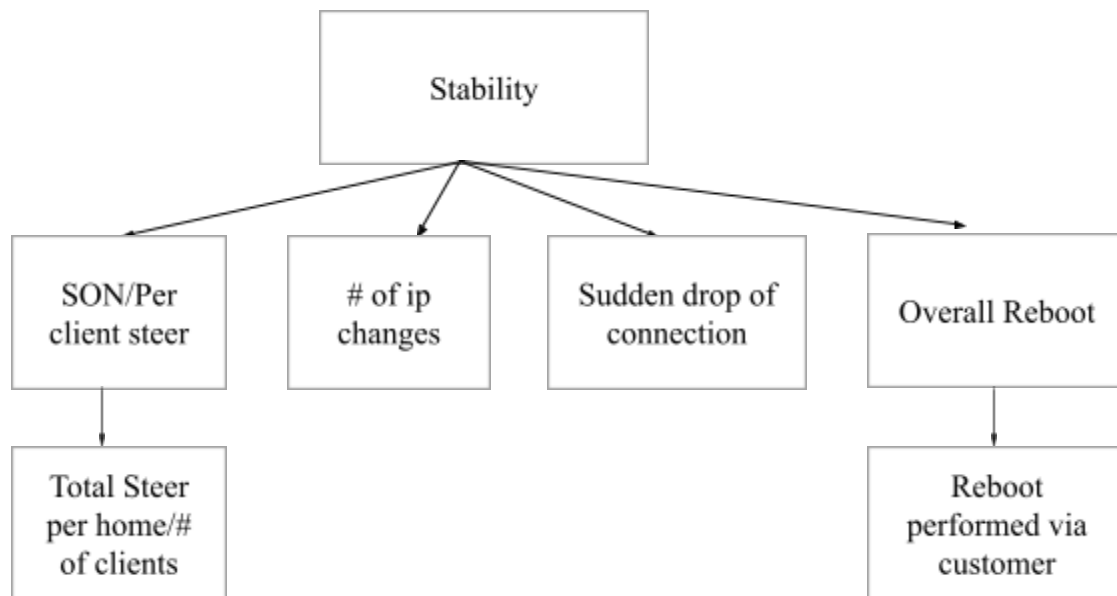


Each block

Reliability/Stability

## Key Features for Reliability/Stability

|   | Feature Name   | Coverage | Speed | Reliability |
|---|--|----------|-------|-------------|
| 1 | SON/Per client steer   |          |       | Y           |
| 2 | Sudden drop of connection - more than 3 clients (stationary) disappeared |          |       | Y           |
| 3 | Reboot performed via customer  |          |       | Y           |
| 4 | Overall reboot   |          |       | Y           |
| 5 | # of ip changes  |          |       | Y           |



**# of ip changes:** Any time an ip change occurs application has to re-negotiate to the back-end server. For example, if a customer is watching Netflix and a WAN ip change occurs it would result in re-negotiation of the link and in turn result in poor customer experience

## Field Data for reference

|         |       |
|---------|-------|
| Titan 1 |       |
| 0       | 79995 |
| 1-3     | 60494 |
| 4-6     | 6445  |
| 7-15    | 2739  |
| 16+     | 706   |

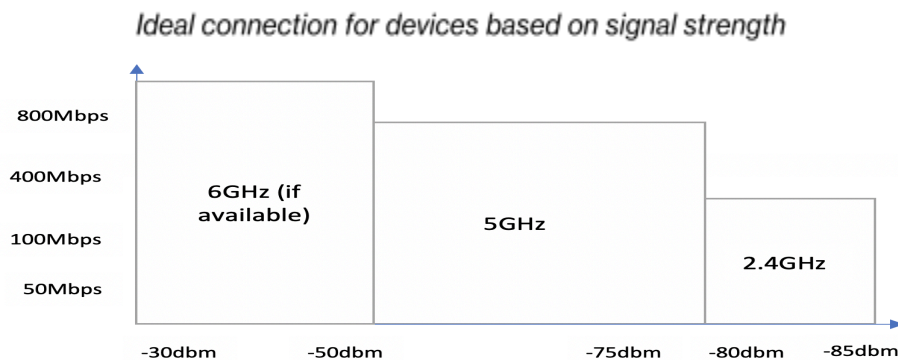
Over 10-day period (Lily/Jeemil - to double sankar what shorter duration)

|   | # of IP changes                   | Poor | Fair | Good | Excellent |
|---|-----------------------------------|------|------|------|-----------|
| 1 | # of IP changes without reboot    | >6   | 4-6  | 1-3  | 0         |
| 2 | # of IP change caused with reboot | >16  | 7-15 | 1-6  | 0         |

### SON/Per Client Steer:

What is SON: SON stands for self-optimizing network. SON performs two actions

1. Band Steering
2. AP Steering



Band Steering: End Client (STA) is asked to move from one band to another based on pre-defined condition so that end client gets optimum range/speed based on location in house

AP Steering: End Client (STA) is asked to move from one device to another i.e. Router to extender or vice-versa

### **Key Goals of Band/AP steering**

1. Assist client to choose best band with regards to Throughput vs Range
2. Help with overall load balancing within house to avoid congestion on 1 band

Overall Field Performance independent of end-client

|                    |
|--------------------|
| Steer Success Rate |
|--------------------|

| Steer Type | Overall Success % | 2.4->5GHz | 5->2.4GHz | 2.4->2.4GHz | 5->5GHz |
|------------|-------------------|-----------|-----------|-------------|---------|
| Band       | 47.8%             | 61.7%     | 30.9%     | N/A         | N/A     |
| AP         | 67.5%             | 74.5%     | 36.3%     | 62.4%       | 70.5%   |

For tracking reliability/stability we would be measuring SON steer (start)

|   | SON End Client                         | Poor  | Fair       | Good       | Excellent |
|---|--|-------|------------|------------|-----------|
| 1 | Per client steer start                 | >60   | 31-60      | 11-29      | 1-10      |
| 2 | Per client steer failure               |       |            |            |           |
| 3 | Total Steer request per Home/Total STA | > 3.0 | 2.0 to 3.0 | 1.1 to 2.0 | 1 or < 1  |

### Sudden drop of connection

In event of total number of clients disappearing from previous sample

|   | Sudden drop of connection              | Poor | Fair | Good | Excellent |
|---|--|------|------|------|-----------|
| 1 | Stationary client                      | >2   | 1    | 0    | 0         |
| 2 | Non-stationary client (minimum 2 or 3) | >2   | 1    | 0    | 0         |

### Reboot:

Reboot of a device can be categorized into 2 buckets

1. Router reboot
2. Modem reset

In each of the above case system/process restart can happen based on the condition. Within overall reboot there are certain reboots which are good pointers to performance impact in home because of user behavior

We have ability to track kind of reboots which are happening in home. For first phase we would look into user-initiated reboot only. For reference below are all the types of reboot

Reference data from field on different types of reboot

| Reboot Cause | % of contribution |
|--------------|-------------------|
|              |                   |
| GUI          | 0.29%             |
| Kernel       | 0.78%             |
| App          | 0.52%             |
| BTN          | 0.81%             |
| Watchdog     | 0.19%             |
| FW           | 2.37%             |
| ACS          | 2.40%             |
| PWR          | 90.99%            |
| Unknown      | 1.64%             |

Categories of reboots which are of additional interest for us based on above data are

1. GUI - reboot was performed via router GUI
2. App - reboot was performed via App
3. BTN- reboot was performed via Button on the router

A reboot generated via above mechanism should be given higher weightage in determining degradation of performance in home

Apart from router for FWA based devices there is in-built modem/CPE component whose performance impact stability of overall devices. In order to monitor stability of CPE device we would track modem resets over rolling window of last 30 days

Reference data for router reboot from field

| #    | # of homes | % of homes |
|------|------------|------------|
| 0    | 69269      | 32.90%     |
| 1    | 55362      | 26.29%     |
| 2-3  | 50890      | 24.17%     |
| 4-5  | 17213      | 8.17%      |
| 6-8  | 9442       | 4.48%      |
| 9-10 | 2529       | 1.20%      |



|     |      |       |
|-----|------|-------|
| 10+ | 5853 | 2.78% |
|-----|------|-------|

Reference data for modem reset from field

| Modem Reset | % of homes |
|-------------|------------|
| 0           | 82.16%     |
| 1           | 10.94%     |
| 2-5         | 5.00%      |
| 6-10        | 0.94%      |
| 11-20       | 0.50%      |
| 21-50       | 0.29%      |
| 51-100      | 0.10%      |
| 100+        | 0.08%      |

Mapping above to determine quality of performance in home

|   | Reboot/Reset (rolling window 30 days)    | Poor | Fair | Good | Excellent |
|---|--|------|------|------|-----------|
| 1 | Number of reboots per home               | 5+   | 4    | 2-3  | >=1       |
| 2 | Number of modem resets per home          | 5+   | 4    | 2-3  | >=1       |
| 3 | Number of reboots initiated via customer | 3+   | 2    | 1    | 0         |

