RET Label
SON Module

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Document Information

Acknowledgements

The following individuals have contributed to this document:

Eric Johnson

Revision Code

All modifications to this document must be made by the work stream Project Manager and recorded in the Document History section below. The version number of the document will reflect the modifications by following the format Revision x, y, where:

X is the first digit, incremented for changes of substance, i.e. technical/procedural issues.

Y is the second digit, incremented when editorial only changes have been incorporated.

Revision History

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0.1	2018-10-22	Eric Johnson	Initial version
0.2	2018-10-25	Eric Johnson	Updated
0.3	2018-12-20	Eric Johnson	Updated
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1. Summary

1.1. Introduction

High level explanation of the use case and purpose of the tool.

This tool automatically corrects the RET Labels in the network to enable downtilts/uptilts of cells. At first, we will only check RETs without labels and cannot otherwise be determined. Eventually we will run nationally once per year (build programs touch all sites periodically).

1.2. Expected Benefit

How this improve the network (kpis) and/or save engineer's time (estimation on time spend/week on activity the module will cover is a great input!).

Correctly label the RET associated with cells to increase the coverage and reduce the interference to improve throughputs and call quality—two key National RAN Performance Goals. This will enable SON modules for Coordinated Coverage and Capacity Optimization (C-CCO) and Cell Outage Compensation. It will also enable engineers to manually tilt cells.

1.3. Challenges

What tasks will be difficult to accomplish.

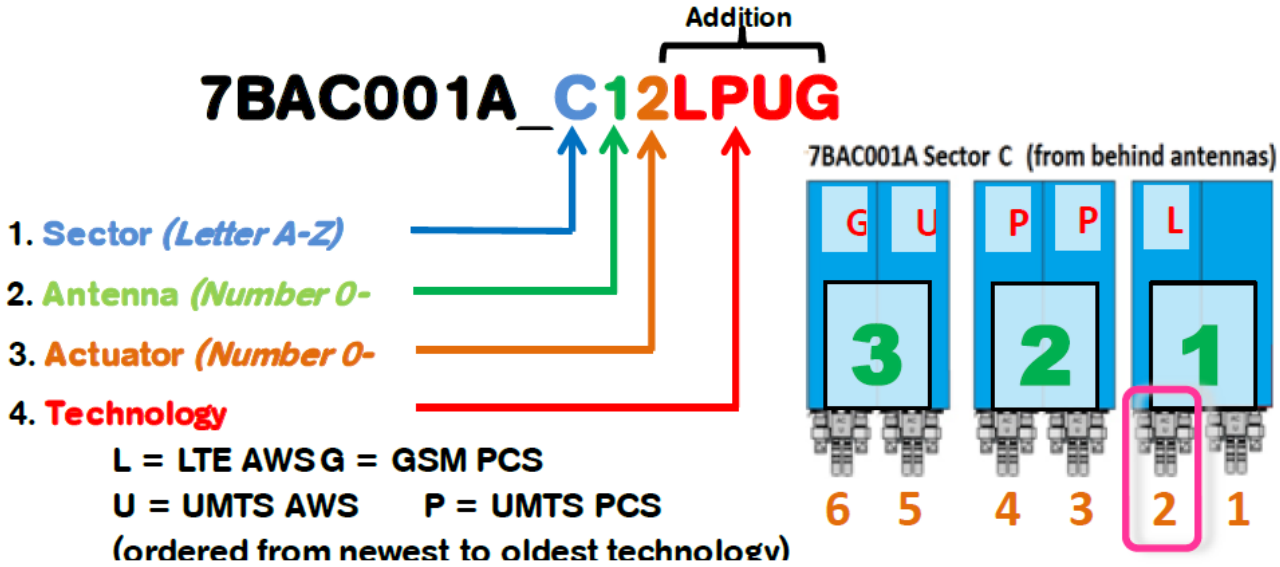
Markets will be resistant to automatic updates until they are confident the tool is doing this correctly. They will also be resistant to tilting cells to find the corresponding coverage because it could negatively impact customers and the RET could jam at an undesired tilt.

2. RET Label Update

The following is the format for the RET Label, and how to update it based on the KPI results from RET tilt changes, and information from the OSS.

2.1. RET Label Format

The following is a diagram of the RET Label format. The format is being changed: Actuator will start from '1' on every antenna. S is used as the technology letter for a RET that is built in the OSS, but does not have any cells actively transmitting on it. There could be 4 different cells connected to the same RET (4 band-tech abbreviations). For example, there could be a Hex-port antenna that has one RET that controls AWS and PCS, and AWS is shared between LTE and UMTS, and PCS is shared between UMTS and GSM.



2.2. Band Nomenclature

Here is the nomenclature for frequency bands.

Band 4: AWS
Band 2: PCS
Band 66: AWS-3
Band 12: 700 MHz
Band 71: 600 MHz

Band to Label lookup
http://niviuk.free.fr/lte_band.php

Site/NodeB/eNobeB level	Cell level	
G=GSM	U = UMTS AWS	Z = NB-IoT AWS
U=UMTS	P = UMTS PCS	Y = NB-IoT PCS
L=LTE	L = LTE AWS	X = NB-IoT 700
	B = LTE PCS	W = NB-IoT 600
	C = LTE 850	
	D = LTE 700	
	E = LTE 600	
	F = LTE AWS 3	
	G = LTE Unlicensed	

2.3. RET Label Update Steps

The following is how to update the RET Label. Priority items to develop first are highlighted in red below.

1. Query RET Labels from 3G OSS and 4G OSS (see following section).
2. Store RET Labels before any changes to them
3. Check if RET Labels correlate to valid cells in the network (see following section).
4. Query LTE handover metrics and calculate the Top 95% neighbors of a cell and ensure any RET tilts do not have significant interactions with other sites having RETs tilted (see following section). Other option, use Nokia Tiering algorithm: don't allow tilts within 5 tiers of each other.
5. Query the OSS to know if there are multiple RET per cell, or multiple cell per RET (see following section).
6. Do the following per Site ID. If the RET Label corresponds for a cell, implement tilt changes on the RET associated with the cell(s), and check the KPI results. If the KPI results corroborate the RET Label to cell mapping then no need to update those RET Labels (see following section).
7. Check for cells with recent changes, and do not tilt these blacklisted cells (see section below). Based on RET change or KPI change.
8. If one RET per cell, then tilt RET one by one on that RET MRBTS where existing RET Label does not correspond to a cell, unless parameter set to tilt all RET on site to confirm labels are correct.
    a. If no match, then tilt in pairs on that RET MRBTS.
    b. (There are a small percentage of cells that use only one of the antenna ports per RET, so they use two RETs even though they do not have 4x4 MIMO or 4x2 MIMO.)
9. If 2 RET per cell, or no matches found with tiling one RET per cell, then tilt RET in pairs for all the RET on that MRBTS where existing RET Label does not correspond to a cell, unless parameter set to tilt all RET on site to confirm RET labels are correct.
    a. If azimuths for two RET are within 20 deg of each other, then tilt as pair first. Otherwise, it does not matter the order to tilt the RET pairs.
    b. If the Max Tilt is greater, then that is the low-band, and the other is the mid-band.
    c. Use antenna model for low-band vs mid-band
10. If find a match between RET and cell, then no need to tilt other combinations of RETs
11. Update RET Label
    a. Only update RET Labels after all RETs to cell correlations are complete for an MRBTS
    b. Antenna and actuator as "01" for the first RET "02" for the second RET
    c. S for spare if no significant change in traffic. How know the difference between RET that is Spare vs RET that cannot be correlated because KPIs not significantly changed? If KPIs not significantly changed, then there will be some RET that cannot be assigned a cell. RET can only be marked Spare if at least one RET is associated with the cell. If technology already marked as "S" or "SPARE" or "NA" or "Not_Used", and confirm no match to cell, then update technology as "S".
12. If changed RET Labels, create an OSS Change Management (CM) plan that can be used to revert the labels back to their original names using the capture of the RET Labels before changes were made (see following section).
13. Update report to show RET Labels that were confirmed as correct, RET Labels corrected, and RET Labels that are wrong but KPI correlations indicating the correct cell.
14. Identify if RETs associated with a cell are not at the same tilt, and difference in tilts. Create plan for engineers to manually run to align them. Use parameter to know if align with higher tilt RET or align with lower tilt RET.
15. Create report of the algorithm results for all the RET to cell correlations. This can be used to analyze the module performance during trials. Report on RET jams for operations, report on RET jam percentage.

2.4. Parameters

The following are parameters for the module

- MW Start Time: When RET tilt can start, typically the maintenance window (MW) start. Default: 12am (midnight)
- MW Stop Time: When RET tilt needs to be reverted to original setting, typically the maintenance window (MW) end time. Default: 5am
- MW Post-Check Time: KPIs will be checked between the MW Stop Time and this time to ensure they are back to normal. Default: 10am
- MW Changes: How many RET changes can be made during one maintenance window period (round to the number that ensures changes are only made on the hour mark). Default: 1
- Scope: Implement RET tilts and KPI check on all sites in the target list, or only implement RET tilts and KPI check on cells where the RET Label does not match a valid cell. Default: Only discrepancies. Other option: All.
- RET Tilt Discrepancies: Many cells have two RET associated with them, and sometimes they have different RET tilts. This parameter determines how to align them. Balanced Alignment chooses high tilt if less than or equal to half the max tilt, chooses higher tilt if more than half the max tilt. Default: Balanced Alignment. Other Options: Align to Highest Tilt, Align to Lowest Tilt, Do not align.
- RET Tilt Discrepance Time: Alignt during label check or not: True/False
- EMS_commit_wait_time_minutes: Time to wait before checking if actual RET tilt matches desired tilt. Use for both test tilt and revert tilt check. Default: 5 min (See C-CCO check as example.)
- Completeness Ratio: Percentage of the KPI evaluation Period, during which valid KPIs are collected, to consider that the amount of data is sufficient. Default: 80%. (See C-CCO check as example.)
- Post Check Time: Time period after end of MW Time to wait to check if KPIs reverted back to pre-tilt values. Default: 6 hrs.
- Neighbor Check: Top 95 or Tiering Algorithm
- Temperature: 35deg.

3. Details for Algorithm Steps

Describe the details of the steps in the algorithm and actions required

3.1. RET Label Query

Query RETs on 4G OSS and 3G OSS. Some LTE cells are controlled by RETs connected to UMTS sites and vice versa. There are no RETs on the 2G OSS. Combine the RET audits from the 4G OSS and 3G OSS.
The OSS has multiple fields to populate per RET, and if some are populated, they can indicate the RET to cell association. The following is an example for Nokia RAN. The Antenna model is populated, so we can know if it is a Hex-port antenna or if is supports a RET. The Max Angle and Min Angle are the Max 95 (i.e. 9.5 deg) and Min (i.e. 0 deg) tilts of the antenna. The Angle is the tilt of the cell (i.e. 4.0 deg).

This OSS audit should be used to ensure that the RET to Cell association from the algorithm is correct. If MIMO is "4-Tx MIMO" (i.e. 4x4 or 4x2 MIMO), then there should be two RET per cell. If the algorithm does not detect two RET, then it should not update the RET Label, and report that it could not assign the RET Label.

RETU_R_BASE_STATION_ID	RETU_R_ANGLE	RETU_R_ANT_MODEL	RETU_R_CNF_DN	RETU_R_MAX_ANGLE	RETU_R_MIN_ANGLE
PH10001A_A23L	40	X17DWV-17DWVS	MRBTS-80285/EQM-1/APEQM-1/ALD-2/RETU-1	95	0
PH10001A_A24L	40	X17DWV-17DWVS	MRBTS-80285/EQM-1/APEQM-1/ALD-1/RETU-1	95	0
PH10001A_B23L	40	X17DWV-17DWVS	MRBTS-80285/EQM-1/APEQM-1/ALD-3/RETU-1	95	0
PH10001A_B24L	40	X17DWV-17DWVS	MRBTS-80285/EQM-1/APEQM-1/ALD-4/RETU-1	95	0
PH10001A_C23L	40	X17DWV-17DWVS	MRBTS-80285/EQM-1/APEQM-1/ALD-5/RETU-1	95	0
PH10001A_C24L	40	X17DWV-17DWVS	MRBTS-80285/EQM-1/APEQM-1/ALD-6/RETU-1	95	0
PH10001A_D23L	40	X17DWV-17DWVS	MRBTS-96640/EQM-1/APEQM-1/ALD-1/RETU-1	95	0
PH10001A_D24L	40	X17DWV-17DWVS	MRBTS-96640/EQM-1/APEQM-1/ALD-2/RETU-1	95	0

The maximum and minimum tilts capable on a cell are constrained by the antenna model. Also, the max tilt may be different for mid-band vs low-band on the antenna. The RET MO has columns for the max/min tilt limits, but they may not be updated properly and could cause the RET to jam.

3.2. Top 95% Neighbors

Avoid tilting cells that will impact other cells being tilted at the same time. Otherwise a RET tilt on a neighbor site might be causing the change in KPI instead of the RET tilt on this site. Query the LTE handover statistics to find the most important neighbors for each site.

3.3. Correlate RET Labels to Cells

Correlate 4G and 3G RET Labels to cells in the network. See Alteryx code.

3.4. Multiple RET per Cell (MIMO)

Multiple Input Multiple Output (MIMO) with 4 transmit and 2 receive antennas (4x2) or 4 transmit and 4 receive antennas (4x4) requires two sets of antenna ports, and thus two RET actuators. This configuration has multiple RET related to one cell. If the dlMimoMode_LNCEL_FDD parameter is 4x4 MIMO or 4x2 MIMO, then there should be two RET for the cell. This is called "4-Tx MIMO" in the queries. For 2x2 MIMO, or no MIMO, this is called "not 4-Tx MIMO" in the queries.

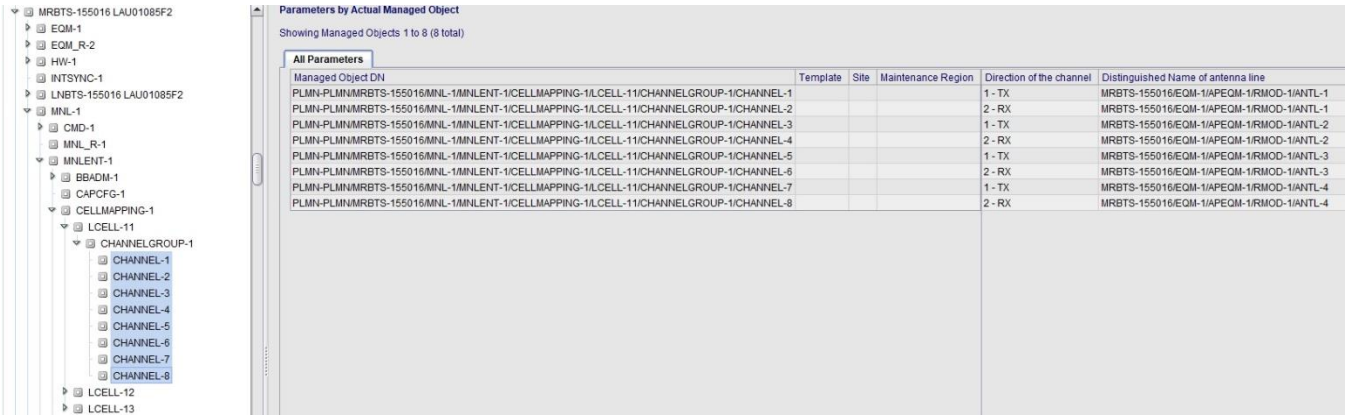
3.5. Multiple Cells per RET (Antenna Sharing)

The primary scenario with multiple cells per RET is from Antenna Sharing. Antenna Sharing is when two technologies are diplexed onto the same RF cables. For example, L1900 may be Antenna Sharing with U1900. This would be indicated by a "B" (for L1900) and a "P" (for U1900) in the RET Label. Another scenario with

multiple cells per RET is from a Hex-port antenna. This antenna has one RET that controls AWS and PCS port-pairs. The OSS has an Antenna Model column in the RET object that we can use to know if a Hex-port antenna is used. The RFDS DB also indicates if a Hex-port antenna is used. The Hex Port antennas used at T-Mobile are the "Nokia FASB Antenna (RAS)" and "Andrew SBNHH-1D65B-SR". Radio modules on the site may also indicate the cell to RET association. For example: FHFB 1900 4-port RRU with LTE and UMTS RETs on UMTS.

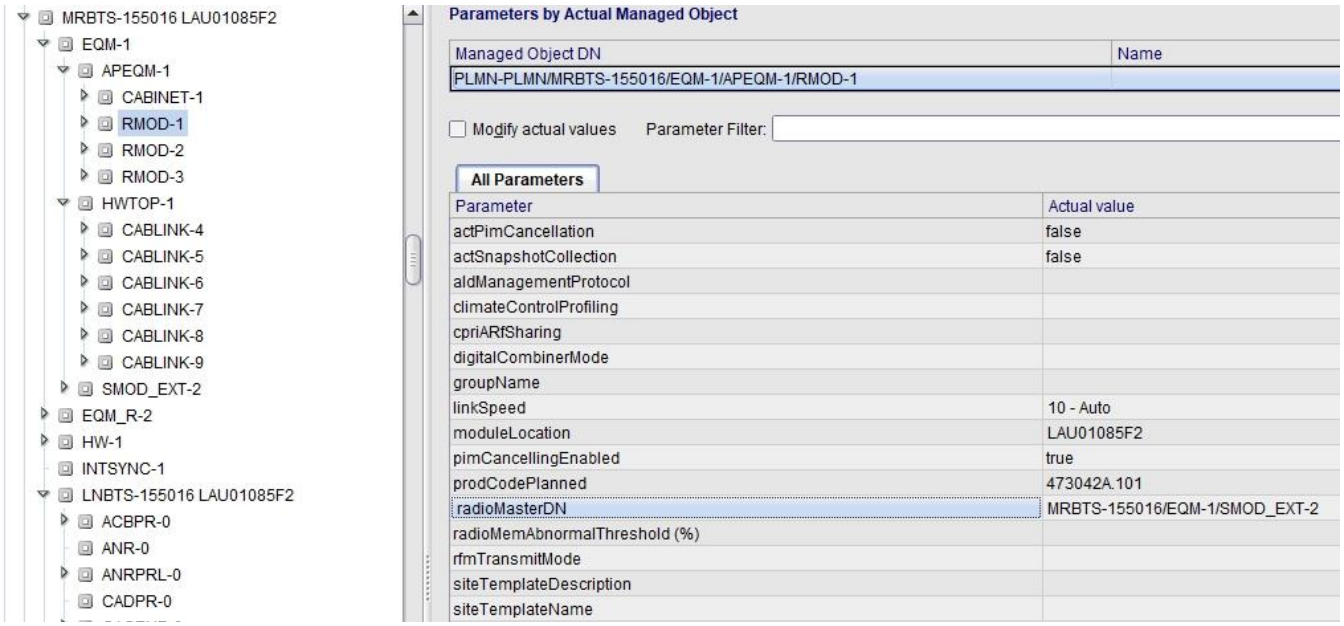
The following are the steps to find Antenna Sharing per cell. See the queries and Alteryx code.

- Pull all cellName under MRBTS/LNBTS/LNCEL
- Pull all RMOD objects under MRBTS/EQM_R/APEQM_R/RMOD
- Any CABLINK with radioMasterDN as "SMOD_EXT%" has RF Sharing
- Link Correlate RMOD_R_CNF_DN and to RMOD in the CABLINK_SECOND_E_PNT_DN
- In the Channel Group, Use the antlDN to find the RMOD, and correlate the LCELL identifier ('11' in example below) with the LCELL
- Add if LTE is sharing with UMTS or GSM from MNL_R_5R64499SRT



Find all the CABLINK that have an "%SMOD_EXT%"

The radioMasterDN will also indicate if there is an SMOD_Ext



The following parameter indicates antenna sharing
sharedRfTechnologies_MNL_R
0: none
1: UTRAN-EUTRA
2: UTRAN-GERAN
3: EUTRA-GERAN
4: UTRAN-GERAN/CONCURRENT
5: EUTRA-GERAN/CONCURRENT
6: EUTRA-EUTRA
7: EUTRA-EUTRA/EUTRA-GERAN
8: EUTRA-CDMA

The Hex Port antennas used at T-Mobile are the “Nokia FASB Antenna (RAS)” and “Andrew SBNHH-1D65B-SR”. In the Nokia RETU_R MO, look in the RETU_R_ANT_MODEL column for “FASB” in the name or “SBNHH-1D65B-SR” Other characters could be included but should be ignored (Ex: “FASB B1/Y1 L” or “Andrew - SBNHH-1D65B-SR”

3.6. No RET capability per Cell

There are some site types or antenna types that do not have a capability for RETs. These will not have OSS managed objects (MOs) built, so there is no action required from this module, but here is some information about this scenario.

Sites not capable of RET
1. DAS
2. Micro cells
3. Pico cells (Ex: Ericsson 6402s)

Antennas not capable of RET
1. Old Antenna Model that doesn’t support RET
2. Old Antenna Model where the RET is AISG1 firmware (needs to be at least 2.0 to work in Ericsson)

3.7. Tilt Cells to Determine RET Label

The following is a process to tilt a cell and check the corresponding traffic to confirm the RET associated with the cell. The module will change only as many cells as allowed by parameters (see above). The parameters may only allow one change per night, and there are multiple RET per site, so this module could be running for multiple days on one site. Multiple sites can have at least one RET tilted per night as long as they do not interact. See section above on Top 95% neighbors. The following are the steps:

- Tilt a RET during the period defined by parameters
- Pull KPIs for all the 2G/3G/4G cells on the cell site (see below)
- Restore the tilt and verify that traffic matches traffic as compared to the same-weekday and same-hour for the previous 4 weeks
- Find the cell with the greatest KPI change as compared to the same-weekday and same-hour for the previous 4 weeks
- Check if the cell derived from this RET Label matches the cell changed
- If different, update the RET Label with the RET Label derived from the cell that changed

Tilt one RET at a time on the site or two RETs at a time (see steps above), and ensure no tilts done on cells with significant interaction related to this site. This is because the change in tilt on this cell will also affect the traffic on neighboring cells, and we need to avoid a false positive from RET changes on these neighbor cells.

Significant interactions are defined as neighbor cells that have the Top 95% highest handover attempts with this cell. Also exclude the other layers associated with those cells. For example, if evaluating LSE01001A11 (an AWS cell), and there are significant neighbor attempts with LSE08000A31 (an AWS cell), then do not allow any simultaneous tilts with LSE08000A31 (LTE AWS), PSE08000A31 (LTE PCS), or DSE08000A31 (LTE 700 MHz). See above for how to pull this data.

Choose the greatest tilt change to have the maximum KPI change. If the cell is close to minimum tilt, then tilt to one less than the maximum tilt. If the tilt is near the maximum, then tilt to one less than the minimum. We want to avoid tilting to the minimum or maximum tilts since we have found that RETs often jam at these extreme values.

Avoid implementing tilts if the temperature is below 35 degrees Fahrenheit. RETs often jam will temperatures fall below freezing.

3.8. Blacklist

Use an outlier detector algorithm to determine if there were significant changes in the last 4 weeks that would influence the KPIs being used. Avoid RET changes on these cells (i.e. blacklist them) and suggest the time that the module could be re-run once it has enough new baseline data to make the evaluation. Changes that could cause these variations include tilt changes or new cells with significant interactions with this site.

3.9. Test Time

Implement the tilt during the maintenance window (MW). Implement the first tilt at the MW Start Time and revert the last tilt by the MW End Time and implement multiple tilts during this time if set (see parameters above). Measure KPIs from MW End Time until 10am and ensure that KPIs from MW End Time to 10am match the same-weekday and same hour as the previous 4 weeks.

3.10. KPIs

Use the following KPIs to identify significant changes that correlate to RET tilt changes.

- LTE: Average Ue Distance
- UMTS: PRACH Propagation Distance
- GSM: Average Timing Advance

3.11. Reporting

Every day create a cumulative report to communicate the audits and changes from the module. The report will have a worksheet for the cells (1 row per cell), RET to Cell (duplicate RET matching cells), RET (one row per RET), Tilts (one row per downtilt/uptilt test), and Check (a list of cells that have an abnormal change in traffic between the MW Stop Time and the Post-MW Check Time). Note if there is a RET Jam so we know where to send contractors to fix them. See report format.

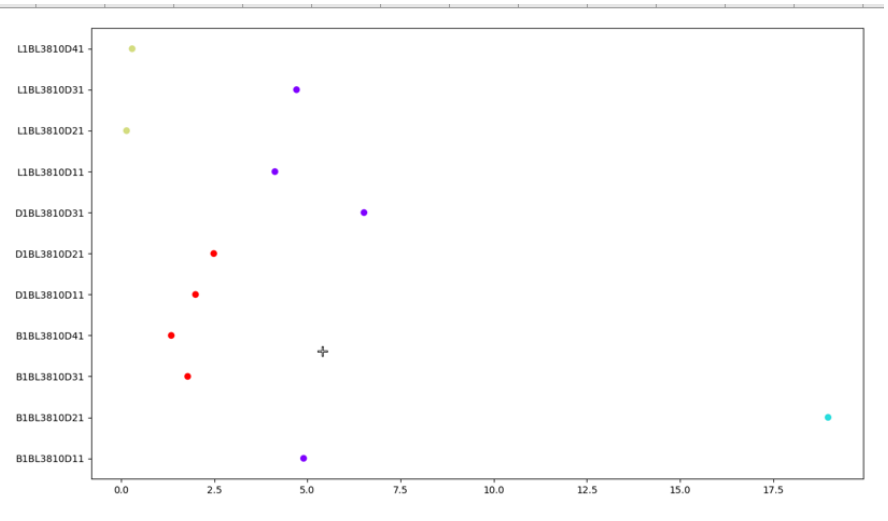
4. Algorithm Results

The following are some results from testing this algorithm.

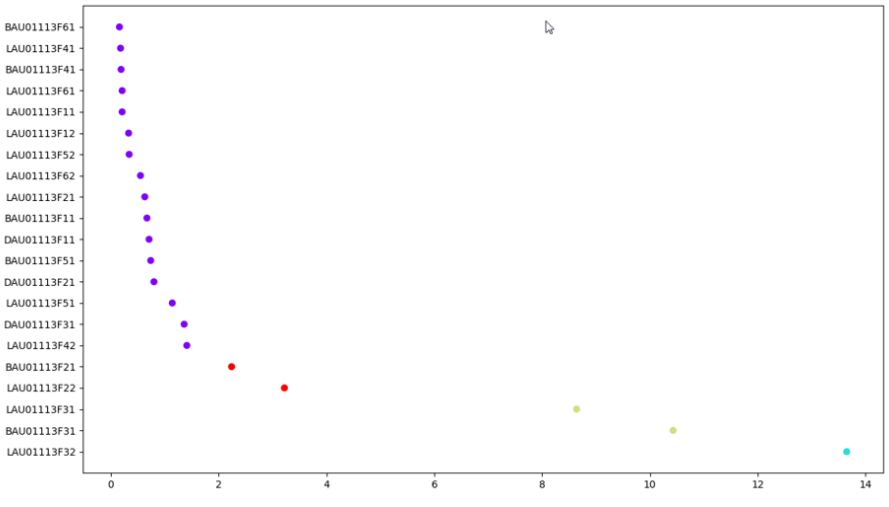
4.1. K-Means Clustering

The following are significant changes found using the K-Means Clustering algorithm. This will be used for the module.

cell_name	Multiple_of_Std_Dev	Cluster_Centroid
B1BL3810D21	18.97	18.97
B1BL3810D11	4.9	5.065
D1BL3810D31	6.52	5.065
L1BL3810D11	4.13	5.065
L1BL3810D31	4.71	5.065
B1BL3810D31	1.79	1.9075
B1BL3810D41	1.35	1.9075
D1BL3810D11	2	1.9075
D1BL3810D21	2.49	1.9075
L1BL3810D21	0.15	0.225
L1BL3810D41	0.3	0.225



cell_name	Multiple_of_Std_Dev	Cluster_Centroid	
LAU01113F32	13.65	13.65	
LAU01113F31	8.64	9.535	4.115
BAU01113F31	10.43	9.535	
LAU01113F22	3.22	2.73	10.92
BAU01113F21	2.24	2.73	
LAU01113F62	0.55	0.601875	
LAU01113F41	0.18	0.601875	
BAU01113F41	0.19	0.601875	
LAU01113F61	0.21	0.601875	
LAU01113F11	0.21	0.601875	
LAU01113F12	0.33	0.601875	
LAU01113F52	0.34	0.601875	
DAU01113F11	0.71	0.601875	
LAU01113F21	0.63	0.601875	
BAU01113F11	0.67	0.601875	
BAU01113F51	0.74	0.601875	
DAU01113F21	0.8	0.601875	
LAU01113F51	1.14	0.601875	
DAU01113F31	1.36	0.601875	
LAU01113F42	1.41	0.601875	
BAU01113F61	0.16	0.601875	



4.2. Multiple of Standard Deviation

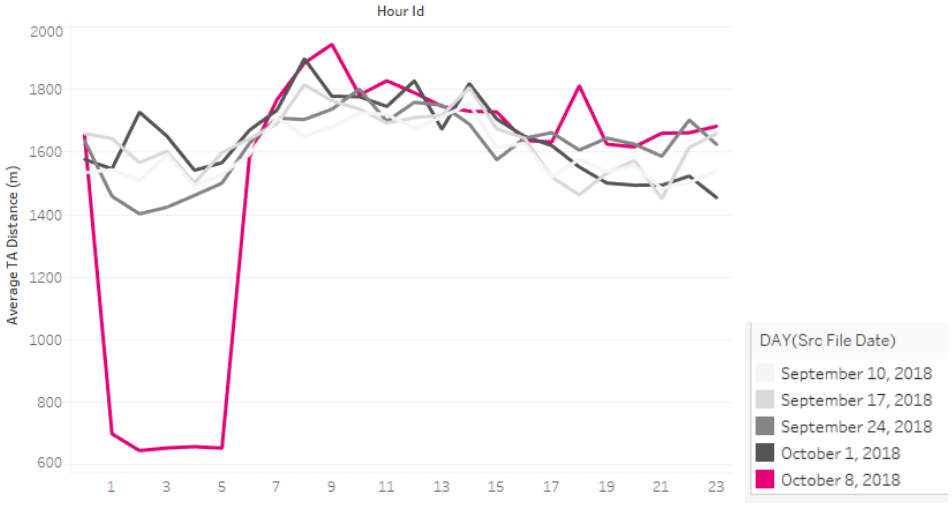
The following downtilt as made on LMW07222A11.

site_id	Label	Tilt Pre	Tilt Post	Tilt Change	Label Length	cell_name_1
MW07222A	MW07222A_A36L	0.8	6	5.2	13	LMW07222A11
MW07222A	MW07222A_A35L	0.8	6	5.2	13	LMW07222A11

The following shows the results of the algorithm for the change. The algorithm finds the median and standard deviation for the period from midnight to 5am for the previous 4 weeks. Then it finds the median of the period from midnight to 5am on the day of the change. Then it calculates the different between the median of the date of change, and the median of the previous 4 weeks, and divides that by the standard deviation to find the "Multiple of the Standard Deviation". The cell with the highest "Multiple of the Standard Deviation" is the cell with the largest change, as shown in green below.

site_id	cell_name	Matches RET Label	Top & > 2	Multiple of Std Dev	Hours Changed	Multiple of Std Dev > 2	Top Changes	rank	Cells Changed per Site
MW07222A	LMW07222A11	TRUE	TRUE	8.27	4	TRUE	TRUE	1	1
MW07222A	DMW07222A11	FALSE	FALSE	3.68	4	TRUE	FALSE	2	1
MW07222A	BMW07222A31	FALSE	FALSE	3.31	5	TRUE	FALSE	3	1
MW07222A	DMW07222A41	FALSE	FALSE	3.12	1	TRUE	FALSE	4	1
MW07222A	DMW07222A31	FALSE	FALSE	2.57	4	TRUE	FALSE	5	1
MW07222A	LMW07222A41	FALSE	FALSE	1.7	2	FALSE	FALSE	6	1
MW07222A	LMW07222A21	FALSE	FALSE	0.97	0	FALSE	FALSE	7	1
MW07222A	BMW07222A41	FALSE	FALSE	0.91	3	FALSE	FALSE	8	1
MW07222A	BMW07222A11	FALSE	FALSE	0.8	0	FALSE	FALSE	9	1
MW07222A	DMW07222A21	FALSE	FALSE	0.78	1	FALSE	FALSE	10	1
MW07222A	LMW07222A31	FALSE	FALSE	0.13	1	FALSE	FALSE	11	1
MW07222A	BMW07222A21	FALSE	FALSE	0.12	0	FALSE	FALSE	12	1

The following shows the hourly results for Timing Advance (TA) Distance for LMW07222A11



The following is the results for the 2nd largest changed cell, DMW07222A11. This is a 700 MHz cell (since it starts with D), and it shows that the other bands, as well as adjacent cells on the same or different bands are absorbing the traffic lost by the downtilted cell. All of these other cells will take only a part of the lost traffic, so they will not have as great of a change as the cell that was changed.