

Slashing Operational Costs via Driveless RAN Optimization

**White Paper** 



## **Executive Summary**

As mobile networks grow in size and complexity, efficient management of daily network operations become one of the most crucial tasks of mobile network operators(MNOs). In this white paper, we discuss how 3GPP defined Minimization of Drive Tests (MDT) data can be utilized in lieu of drive testing to realize *driveless Radio Access Network (RAN) optimization*. The approach outlined here does not require GNSS (Global Navigation Satellite System) location information from mobile terminals or applications. Field results obtained by North American Tier-1 mobile operators have shown that more than 50% reduction in operational expenses is possible from drive test elimination when introducing new sites/clusters.

### **Introduction to MDT**

LTE continues to grow faster than any other mobile communications system technology in history since its introduction in December of 2009. As of January 2016, 480 operators have commercially launched LTE systems, reaching to 13% of mobile connections worldwide. Similar to 3G, LTE deployments introduce significant operational and capital expenditures for mobile operators. Traditionally, test terminals are used to measure signal and service quality levels (e.g. RSRP, RSRQ, SINR, throughput, access fails and drops) during LTE deployments. Drive test logs are collected and analyzed to rectify any issues encountered. This is a very tedious process where large log files need to be handled and analyzed with post processing tools to come up with conclusions. In practice, the whole drive testing process has to be repeated several times due to equipment misconfigurations, failures noticed from earlier tests and important routes which were not driven previously. Also, after each time RF related optimization changes are applied (e.g. electrical antenna tilt changes), drive testing analysis is typically re-run to assess the new results from the field.

3GPP, a global partnership that defines the rules of today's mobile communications systems, specified the standards of how LTE networks should produce data to minimize traditional drive testing efforts under the Minimization of Drive Tests (MDT) initiative.

In this white paper, we discuss how 3GPP defined MDT data can be used to implement a "driveless" RAN optimization framework for mobile operators to dramatically reduce their operational expenses.



## **Shortcomings of Drive Testing**

Since the 1990s, mobile subscribers have experienced a dramatic increase in network capacity, starting with 9.6 Kbps CS download rates in GSM to more than 300 Mbps with LTE-A. However, RAN optimization processes to `tune` mobile networks have not changed much within this period to keep up with the advancements.

In a typical LTE network deployment scenario, the first step is to design the network while taking into account the expected subscriber base, service quality committed to end users, and the RAN budgets, the most expensive part of CapEx. Then, eNBs are deployed as designed and budgeted typically with lower density over an existing 2G/3G radio network layer. At this 'pre-launch' phase, drive tests are performed to simulate subscriber behavior and to identify any immediate issues with the deployment. Following the commercial launch of planned sites, more eNBs are gradually added to enhance both the coverage and the capacity of the network while introducing minimum disturbance for commercial users. Unless the parameters are properly tuned, new site additions can potentially disturb existing neighborhood sites. Because of the need to test the footprint of each added site's coverage, drive testing becomes an important task in this phase.

Shortcomings of drive testing during this 'post-launch' phase are as follows:

<u>Long testing duration required</u>: Assuming an urban region with average site-to-site distance of 1-3 miles where 200 eNBs are on-aired, every new eNB added to the region after cluster launch requires an average of 10-15 miles of drive testing (excluding drives to get/return to the site). This corresponds to 1,000 - 1,500 miles of driving if 100 eNBs are added. This significantly increases the time it takes the MNOs to realize revenues from the new assets added.

<u>High volumes of data to process</u>: If we consider that Tier-1 operators have thousands of eNBs, the amount of drive test data that is required to be collected and analyzed amounts to huge volumes. For a 25-eNB urban cluster in a 3 miles x 1 miles area with 4 pieces of test equipment including a scanner searching three separate bands, the amount of drive data can exceed 1 GB of raw files for a 7-hour drive.

<u>Sampling limitation</u>: It may take a large number of tests to be repeated in order to replicate a specific drop or a block problem. More tests mean more logs and consequently result in wasted resources.



<u>Indoor user experience</u>: Drive testing is performed in outdoor environments. However, the majority of subscriber traffic takes place indoors. Thus, conventional drive testing approach cannot verify and improve indoor subscriber experience.

## MDT as a Driveless Solution for Post-Launch Optimization

As a response to the shortcomings of drive testing, 3GPP published Minimization of Drive Tests (MDT) specifications [1, 2, and 3] to provide a more efficient approach to optimization. Using the measurements taken from MDT-supported equipment, operators can select and display all or a portion of the UEs (User Equipment) under specified eNBs covering a particular geographical region or specific IMSIs, IMEIs or IMEI-TACs [4] across the network. These standardized UE and equipment measurements are then used for various needs including new site/cluster RF Tuning or VIP customer complaint handling. The output measurements of MDT are also normalized to be used as inputs to SON (Self Organizing Networks) use cases and algorithms such as CCO (Coverage and Capacity Optimization) [5, 6].

Driveless MDT optimization complements the mobile operator's 'post-launch' deployment process as follows:

- Step 1. Site installation and eNB integration to OSS
- Step 2. Identification and resolution of hardware issues (e.g. PIM, RSSI, VSWR)
- Step 3. eNB and MME configuration audits (e.g. golden parameters, TAC, PCI, RSI)
- Step 4. Pre-launch single site audit (e.g. crossed feeder/MIMO verification, stationary DL/UL throughput check, testing of Tx imbalance issues, co-site handover check)
- Step 5. eNB and cluster launch
- Step 6. Post-launch optimization with driveless MDT data

Once an eNB or cluster is launched for commercial traffic, driveless RAN optimization process starts. MDT configuration is done by specifying eNB/E-UTRAN cell list, time, duration of measurement, messages, events to be collected over Uu and eNB external interfaces and sampling rate of calls (e.g. 50%). Typically, files are created per 15-minute intervals on eNBs and then forwarded to OSS (Logged MDT). Streaming transfer option directly to an external server is also defined in the standards (Immediate MDT).

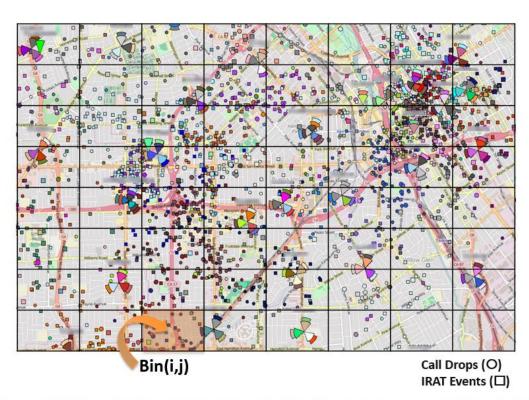


KPI results are calculated and analyzed per geographic bin where resolution depends on operator requirements (e.g. ranging from 50m x 50m to 500m x 500m).

Various Key Performance Indicators (i.e. KPIs¹) ranging from availability, accessibility, retainability, mobility, integrity and throughput for different services (e.g. PS Data, VoLTE, CSFB) should be above target performance thresholds set by the mobile operator for best subscriber experience.

An important benefit of the driveless approach is that, the operator can improve service quality experienced by subscribers in every part of the network per geographic bin. Driveless post-launch optimization improves bad subscriber experience even for cells with very good network KPIs, which reflect the accumulated results of all subscribers in a cell.

Additionally, geographic bin analysis facilitates policy tuning per bin, where important KPIs (e.g. throughput and coverage) are weighted with larger coefficients than others during the calculation of a unified quality index per bin.



Cost of Bin(i,j) = Weight(KPI<sub>1</sub>)xKPI<sub>1</sub> + Weight(KPI<sub>2</sub>)xKPI<sub>2</sub> + ... + Weight(KPI<sub>N</sub>)xKPI<sub>N</sub>

Figure 1 - Cost calculation example for a geographic bin

<sup>&</sup>lt;sup>1</sup> 3GPP initial output to extend traditional KPI definition to Service Experience KQI is described under TR 32.862. [7,8]



The following Figure 2 - Drive Testing vs. Driveless Tuning of a newly added site/cluster to commercial network compares Drive Testing with driveless MDT based network tuning to emphasize the shortened duration and minimized effort of the driveless solution.

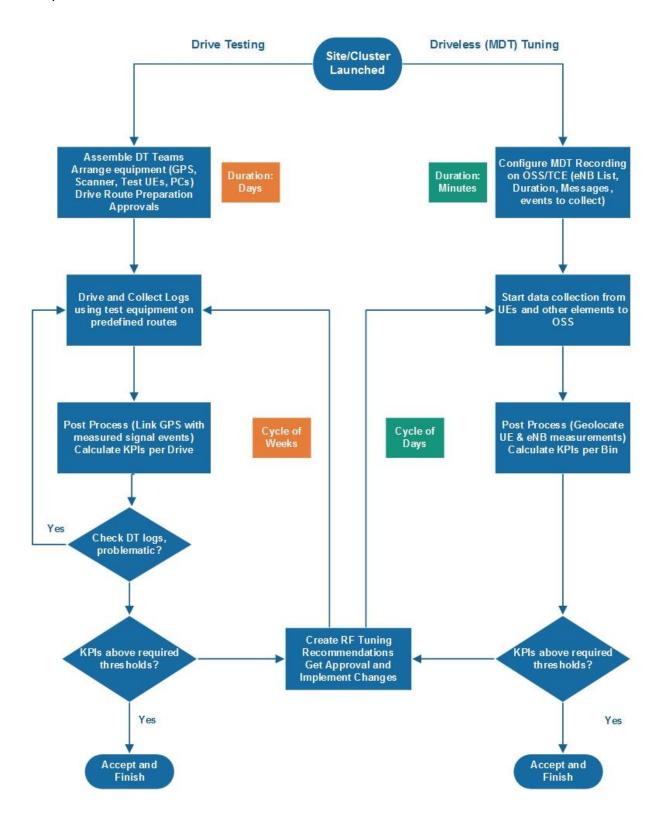


Figure 2 - Drive Testing vs. Driveless Tuning of a newly added site/cluster to commercial network



## **Comparison of MDT Alternatives**

Some alternative solutions to MDT with their pros and cons are provided below:

*Probe systems:* This solution requires external equipment to be deployed in the RAN and the Core Network. It is useful for end-to-end verification of applications and troubleshooting, but lacks all other requirements of a new site and cluster `post-launch`. The cost is high.

*Geolocation tools:* Typically, these solutions focus on visualization of events such as drops, blocks, throughput and radio coverage for reporting and troubleshooting purposes. They lack the capability to automatically update RF parameters needed to bring improvements to the network.

SON tools without geolocation support: SON solutions that do not support geolocation have the capability to provide some RF tuning recommendations such as dynamically tuning mobility thresholds, offsets or hysteresis. These tools lack cell footprint visualization and optimization capabilities as required by new site and cluster `post-launch` processes.

Support for	Traditional Drive Test tools	Probe systems	Geolocation tools	SON tools w/o Geolocation support	Driveless MDT solution
New site & Cluster RF Tuning (visualization of drop, block events and coverage on map)	Yes	No	Yes	No / Limited	Yes
Provide RF tuning recommendations	No	No	No	Yes	Yes
Compatibility with other SON functions such as CCO	No	No / Limited	No / Limited	No	Yes
Verify indoor customer experience	No	No	Yes	No	Yes
VIP customer complaint handling	No / Limited	No / Limited	Yes	No	Yes
End to end verification of applications and troubleshooting	Yes	Yes	No	No	No
Competitor benchmarking	Yes	No	No	No	No

Table 1 - Comparison of Driveless MDT solution with other alternatives



# Case study: Downlink throughput verification and tuning using driveless optimization

Following figures depict driveless MDT data analysis results of a cluster during post-launch optimization. Figure 3 shows the first carrier cells in low band (800 MHz) whereas Figure 4 shows the second carrier cells in the high band (1800 MHz) of the same eNBs in the cluster. Subscribers' downlink throughput values per bin are optimized during post-launch, which takes into account configured band priorities. (i.e. for the high priority 1800 MHz band, subscribers shall be served close to site, whereas 800 MHz band subscribers shall be served mostly at cell borders)

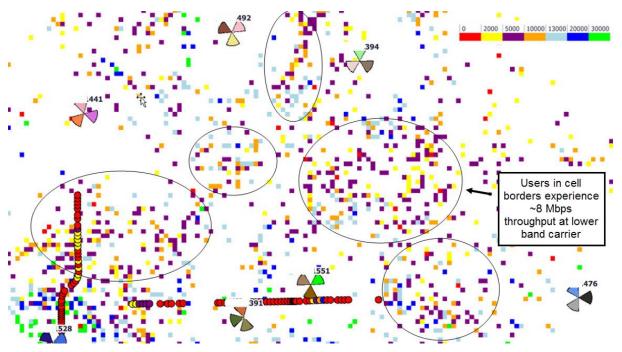


Figure 3 - User downlink throughput (purple: 5Mbps to 10Mbps) on base 800 MHz band LTE carrier cells

As shown in Figure 2, subscribers served at cell edge areas (either outdoor or indoor) on the 800 MHz band experience 5 to 10 Mbps throughput. Other subscribers that are close to cell center areas enjoy downlink throughput rates higher than 30 Mbps on the 1800 MHz band. With this band separation, user location and user throughput, the operator can control the quality of experience of subscribers as a result of detailed band, location and throughput view in the post launch cluster. In accordance with operator policies, recommendations in the form of electrical antenna tilt and power changes are applied to improve subscriber experience.



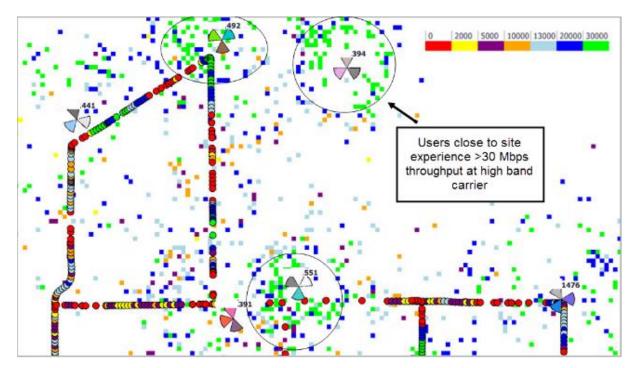


Figure 4 - User downlink throughput (green: >= 30Mbps) on overlay 1800 MHz band LTE carrier cells

Drive test throughput measurements are also correlated on the same map using the same colored legend. Due to the inherent mobility of drive tests, downlink throughput testing results obtained around the same locations are worse than the throughput observed by MDT UEs, which are mostly stationary.

These observations provide valuable insight as to how traffic and throughput is dispersed over the testing region. Further, it also helps to verify the layer management strategies of the operators. In this specific example, subscribers on high band carrier that are served close to site experience greater than 30 Mbps throughput whereas subscribers at cell borders get around 8 Mbps throughput on low band carrier. Without detailed breakdown of UE provided data, overall computed KPIs would not provide the details on how the throughput is divided among subscribers. Improvements can be fine-tuned based on MDT data obtained from UEs in various periods and durations.



### Conclusion

Driveless optimization based on MDT data is an efficient way to handle the performance tuning and verification of today's mobile networks of growing complexity, compared to traditional drive test based methods. Using MDT, the cost and the duration of post-launch optimization process is greatly reduced. This provides faster roll out times with optimum user experience.

MDT data provides the framework where hidden problems in the network are revealed and effective solutions are implemented in a quick and cost efficient way. This approach accumulates measurements from all subscribers throughput the network as opposed to a drive testing performed with limited number of test UEs on limited regions.

P.I. Works has extensive expertise in post-launch optimization using MDT data with various operators. For more information, please <u>contact</u> P.I. Works for Driveless RAN Optimization Solutions.

### **About P.I. Works**

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P.I. Works, is a leading provider of next-generation Radio Access Network (RAN) management solutions. P.I. Works' expertise in mobile network optimization, which spans over a decade, combined with the commercially available product portfolio and services, enables global Mobile Network Operators (MNOs) to improve network quality and subscriber experience, while increasing profitability.

To date, P.I. Works has deployed its solutions for 38 MNOs in 27 countries.

P.I. Works state-of-the art product portfolio, unified Self Organizing Networks (uSON<sup>™</sup>), automates the optimization and operational tasks of complex mobile networks 24/7 to increase quality, capacity and coverage.

For more information, please visit <a href="http://www.piworks.net/">http://www.piworks.net/</a> or send e-mail to <a href="mailto-sales@piworks.net/">sales@piworks.net/</a>

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### References

- [1] 3GPP TS 32.421: Subscriber and equipment trace: Trace concepts and requirements
- [2] 3GPP TS 32.422: Subscriber and equipment trace: Trace control and configuration management
- [3] 3GPP TS 32.423: Subscriber and equipment trace: Trace data definition and management
- [4] S5-112666 TS 32.422: Enhancement for MDT Initiation with IMEI-TAC usage [P.I. Works contribution to 3GPP, Aug 2011]
- [5] S5-154288 TS 28.628 Add NM-Centralized CCO related measurements and delete redundant ones [P.I. Works contribution to 3GPP, Aug 2015]
- [6] S5-154289 TS 28.628 Correct coverage hole definition for NM centralized Coverage and Capacity Optimization (CCO) [P.I. Works contribution to 3GPP, Aug 2015]
- [7] 3GPP TR 32.862: Study on Key Quality Indicators (KQIs) for service experience
- [8] S5-153343 TR 32.862 pCR 32.862 NGMN Service Quality Definition and Measurement for HTTP Adaptive Streaming [P.I. Works contribution to 3GPP, May 2015]