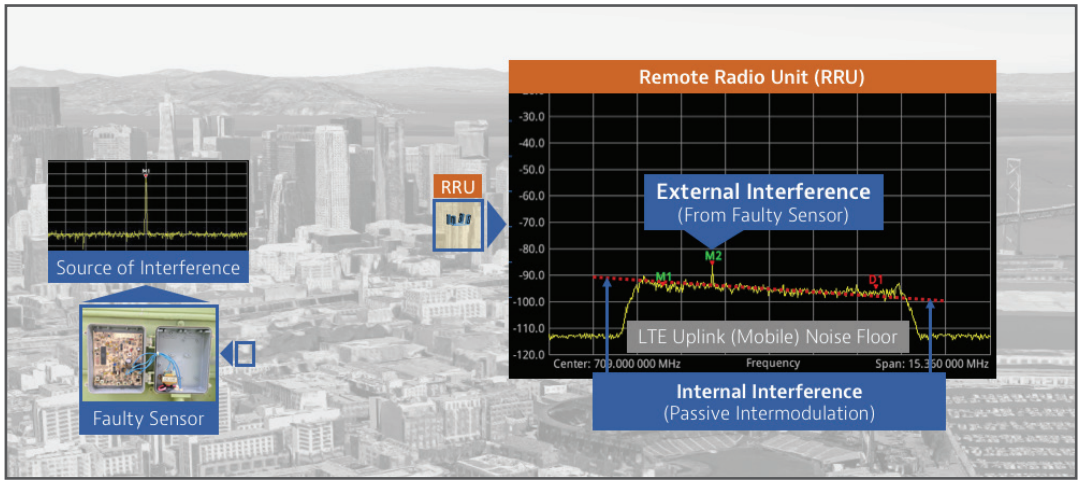
Increase RF Visibility with CPRIAdvisor

Interference in Radio Access Networks

Wireless communication systems utilize the air interface to exchange data by transmitting modulated signals over carriers or channels on defined frequencies in the spectrum. Mobile operators have licensed spectrum reserving the corresponding frequency ranges to provide cellular services.

However, this licensed spectrum is subject to interference from multiple sources that can be grouped in two main categories:

- Internal interference, which is typically generated by non-linearity in the transmission system of cell-sites, including radios, amplifier, cabling, duplexers, connectors, and antennas. This creates intermodulation as products of mixing signals that can be at the same frequency as mobile devices, resulting in collisions or interference that affect service in terms of coverage and capacity.
- External interference, generated by transmitters external to the cellular network. This can include faulty equipment generating harmonics such as broadcast FM radios, or oscillators shifted in frequency such as residential AC power controllers, or even harmonics from industrial machinery that generate intermittent signals in the same frequencies used by mobile terminals.



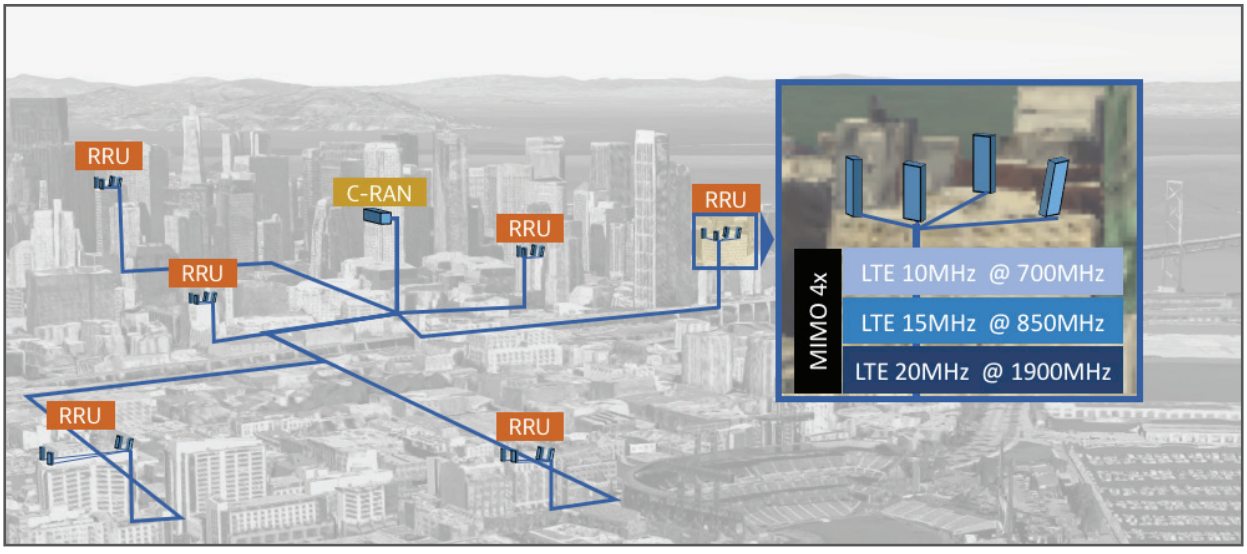
External interference from AC controller and internal interference from PIM

Interference in cellular networks is one of the most common problems in the radio access network (RAN), and is becoming a major concern due to the network's complexity and constant transformation to increase mobile service's coverage and capacity, including:

a. Adoption of new technologies such as the transmission and reception from multiple antennas (MIMO 2x, 4x, and 8x)

b. Allocation of multi-band spectrum (Bands 12, 13, 14, 17, 28, 44, 60: 700MHz, Bands 5, 6, 8, 18, 19, 20, 26, 27: 800 MHz, Bands 3, 4, 10, 66, 70: 1710MHz, Bands 2, 25, 35, 39: 1800MHz, Bands 1, 33, 36, 37, 65: 1900MHz, Bands 23, 34: 2000MHz, Bands 30, 40, : 2300MHz, Bands 7, 38, 41: 2500MHz, Bands 22, 42: 3400MHz, among others).

c. Centralization of signal processing migrating conventional macro-cells into distributed cell sites with fiber front-haul, where the base band unit (BBU) is in the central office or cabinets and the remote radio units (RRU) are deployed close to the antennas. Gradually, the RAN is evolving into a centralized radio access network (C-RAN) with a star topology with a group of BBUs controlling remote radios distributed in wide areas such as cities, stadiums, hospitals, airports, shopping centers, college campuses, and enterprises, among others.



CRAN topology with multi-band MIMO radios

RF Visibility in Radio Access Networks

The ability to have visibility of the radio spectrum with the accuracy and speed needed to properly detect and identify interference is becoming essential to provide mobile services with quality of experience; however, the time available for maintenance and problem solving has been significantly reduced, creating the need to improve operational efficiencies. primarily through the following practices:

- Continuous spectrum monitoring with the ability to enable key performance indicators to prevent network degradation or problem identification. This includes optical signal strength at the remote radios, received signal strength of the mobile spectrum, and continuous spectrum monitoring through time to characterize intermittent interference signals.
- Remote access to promptly identify incidence of interference and provide spectrum visibility to remote network experts. This expedites problem resolution while providing the ability to verify in real time repair activities performed at remote sites, reducing costs associated with multiple site repairs and service downtime.

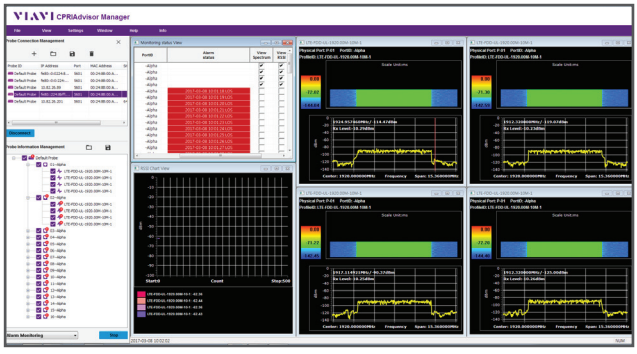
Driven by the network densification and transformation to C-RAN, as well as the above maintenance practices to ensure quality of service, Viavi has developed CPRIAdvisor, an RF test solution that increases RF visibility by performing continuous monitoring of the mobile spectrum and allowing remote access to expedite maintenance and problem resolution.

CPRIAdvisor is based on network probes with RF over Fiber (RFoFiber) technology, and is able to de-map RF components from fiber front-haul (CPRI or OBSAI), with flexibility in port density, providing solutions to any type of cell-site, including:

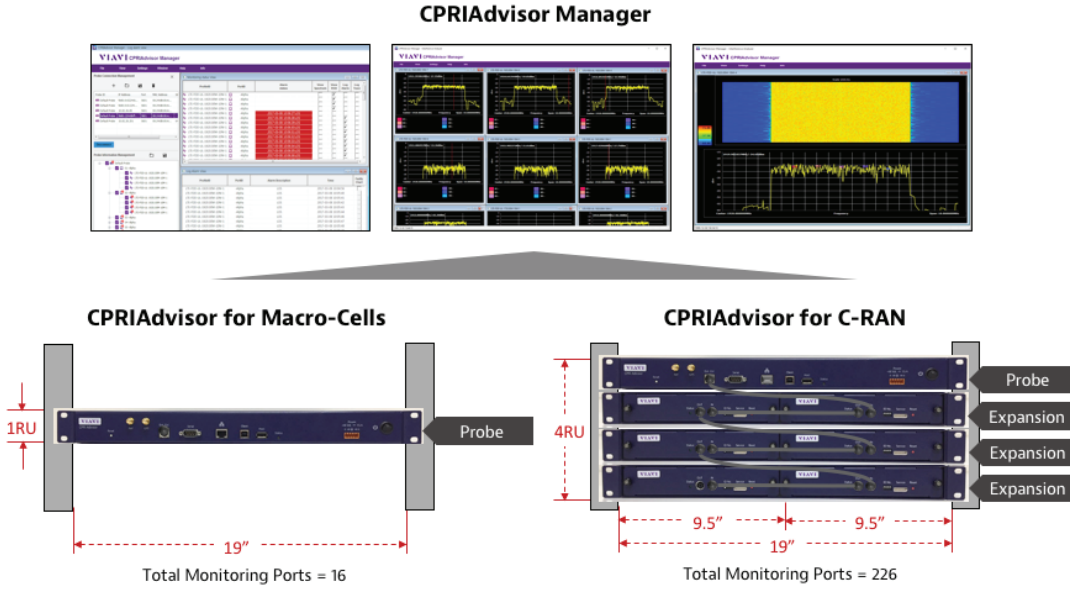
- Macro Sites, typically designed with 3 sectors and providing services in 3 to 4 bands for a total of 9 to 12 front-haul fibers with mobile traffic. A CPRIAdvisor with a single probe can monitor up to 16 RFoFiber links in a single rack unit space
- Small DAS, typically deployed in the enterprise with 10 to 80 front-haul fibers with mobile traffic. A CPRIAdvisor probe with 2 expansion modules can monitor up to 86 RFoFPRI links in a 2-rack space.
- Big DAS or C-RAN, typically deployed in large venues such as stadiums with 80 to 200 front-haul fibers with mobile traffic. A CPRIAdvisor probe with 4 expansion modules can monitor up to 226 RFoFiber links in a 4-rack unit space respectively.

CPRIAdvisor Probe

CPRIAdvisor Probe and Expansion



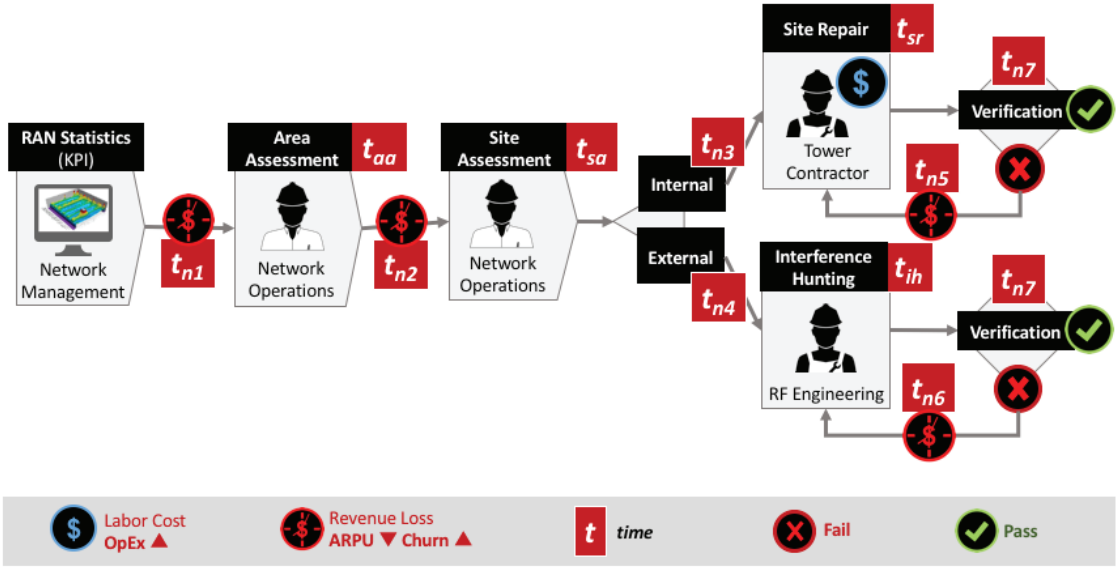
CPRIAdvisor Manager



CPRIAdvisor in macro-cells and C-RAN

CPRIAdvisor Benefits

The following example illustrates the conventional maintenance process related to interference, including internal and external interference and corresponding site repairs or interference hunting respectively, with associated average time and cost.



Conventional maintenance process for interference

Conventional maintenance cost for internal interference (PIM)

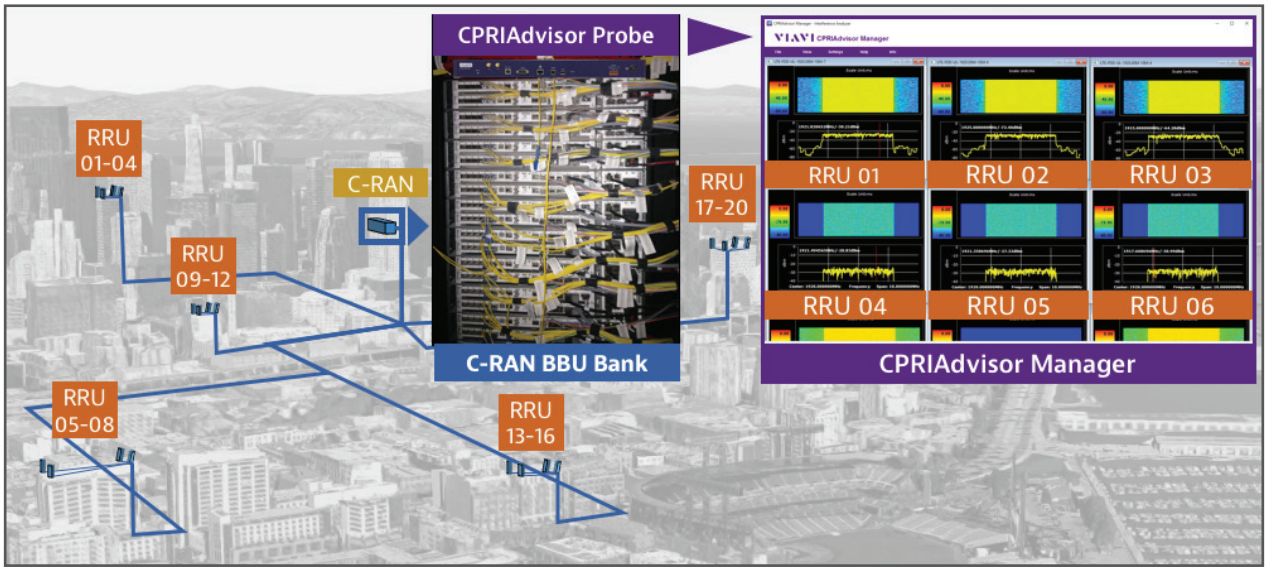
Maintenance Stage	Days	Revenue Loss	Churn Cost	Labor	Total Cost
t_{n1} : time of notification for area asessment	1	$333.33	$33.33		$366.67
t_{aa} : time for area assessment	1	$333.33	$33.33		$366.67
t_{n2} : time of notification for site assessment	1	$333.33	$33.33		$366.67
t_{sa} : time for site assessment	1	$333.33	$33.33		$366.67
t_{n3} : time of notification for repair	5	$1,666.67	$166.67		$1,833.33
t_{sr} : tower crew visit/repair	1	$333.33	$33.33	$3,000.00	$3,366.67
t_{n7} : time of notification for repair verification	1	$333.33	$33.33		$366.67
Total Time and Cost	11	$3,666.67	$366.67	$3,000.00	$7,033.33
t_{n5} : time of notificatio for repair	5	$1,666.67	$166.67		$1,833.33
t_{sr} : tower crew visit/repair	1	$333.33	$33.33	$3,000.00	$3,366.67
Total Time and Cost	17	$5,666.67	$566.67	$6,000.00	$12,233.33

Cell-Site Maintance Cost Model

Cost Model Variables	
Subs per cell-site	1000
Subs affected	20%
Churn per month	10%
Cost of tower climb	$3000
Monthly ARPU	$50

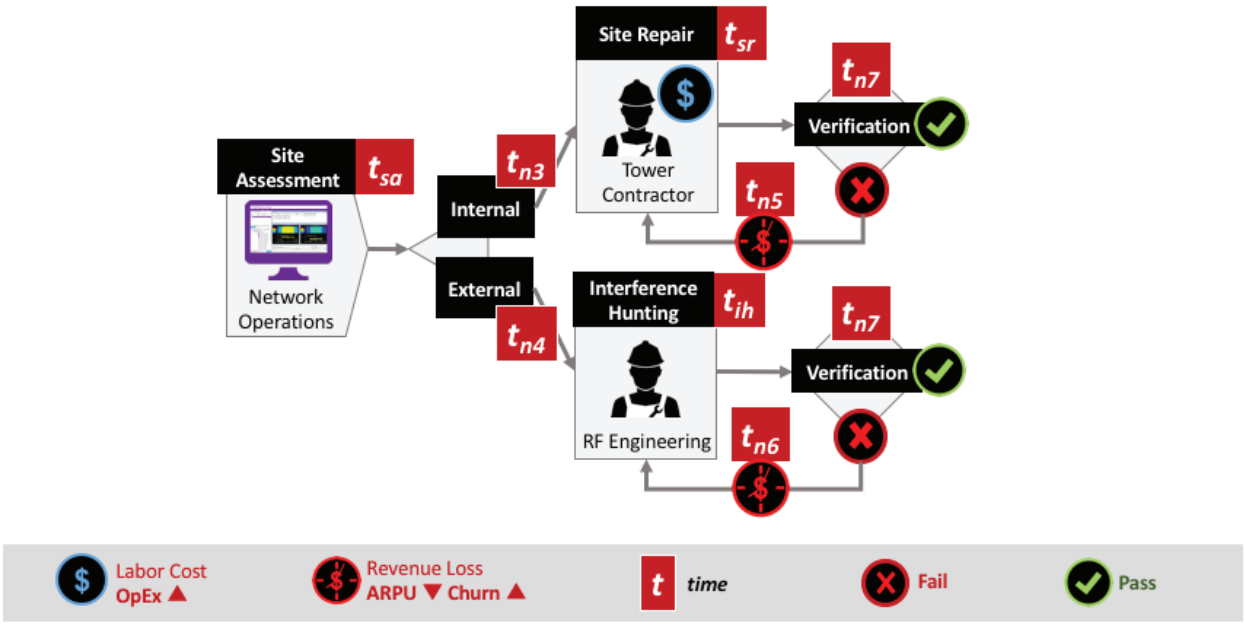
- **RAN Statistics (KPI)**, the centralized management system tracks key performance indicators (KPIs) related to mobile services, including received signal strength indicator (RSSI) or received total wideband power (RTWP) which represents the power level of uplink channels. In the presence of interference, the value of these indicators will increase and a maintenance ticket or notifications (t_{n1}) will be sent to the affected area for assessment and resolution.
- **Area Assessment**, network operations receives the notification from RAN Statistics (KPI) and conducts the corresponding assessment (t_{aa}) of the radio or cluster of radios that reported high RSSI or RTWP. Based on network conditions, maintenance processes, or events in the affected area possible causes are identified, and a notification is sent to local maintenance of the sites (t_{n2}) to conduct further analysis and resolution.
- **Site Assessment**, local network operations performs maintenance procedures (t_{sa}) at the site, such as spectrum analysis in the uplink noise level to properly characterize the type of interference. In case of internal interference, a notification (t_{n3}) or request is sent to contractors for site repair; or in case of external interference, a notification (t_{n4}) or request is sent to RF engineering for interference mitigation.
- **Site Repair**, spectrum analysis of the uplink with a distinct PIM signature is repaired by contractors that perform tests and repairs/replacements of cable and antenna systems; since this repair is commonly done at the top of the tower, it requires time (t_{sr}) to schedule, then repair the site.
- **Interference Hunting**, spectrum analysis of the uplink with interference received in all the antennas of the sector is an indicator of external interference and might have distinct characteristics in frequency and time, which are analyzed by RF Engineering to assess the type of interference and define the best methodology to test (peak search, RSSI, channel power) and perform an interference hunting process (t_{ih}) for its location and mitigation.
- **Verification**, after the site has been repaired, or internal interference (PIM) or external interference has been located and mitigated, network operations performs an uplink spectrum test (t_{n7}) to verify the spectrum is clear of interference; and will conduct additional repairs (t_{n5}) or interference hunting (t_{n6}) as required.

CPRIAdvisor provides visibility of the radio spectrum from multiple sectors with the accuracy and speed needed to properly detect and identify interference, applicable for any cell sites, DAS and C-RAN.



CPRIAdvisor in C-RAN

CPRIAdvisor's continuous monitoring and remote access capabilities effectively simplify the process and reduce cost of maintenance for interference.



Maintenance process with CPRIAdvisor for interference

Maintenance cost with CPRIAdvisor for internal interference (PIM)

Maintenance Stage	Days	Revenue Loss	Churn Cost	Labor	Opportunity Cost
t_{n1} : time of notification for area asessment	0	$–	$–		$–
t_{aa} : time for area assessment	0	$–	$–		$–
t_{n2} : time of notification for site assessment	0	$–	$–		$–
t_{sa} : time for site assessment	1	$333.33	$33.33		$366.67
t_{n3} : time of notification for repair	5	$1,666.67	$166.67		$1,833.33
t_{sr} : tower crew visit/repair	1	$333.33	$33.33	$3,000.00	$3,366.67
t_{n7} : time of notification for repair verification	0	$–	$–		$–
Total Time and Cost	7	$2,333.33	$233.33	$3,000.00	$5,566.67
t_{n5} : time of notificatio for repair	0	$–	$–		$–
t_{sr} : tower crew visit/repair	0	$–	$–	$–	$–
Total Time and Cost	7	$2,333.33	$233.33	$3,000.00	$5,566.67
Time Improvement	59%		Cost Improvement		54%

Cell-Site Maintance Cost Model

Cost Model Variables	
Subs per cell-site	1000
Subs affected	20%
Churn per month	10%
Cost of tower climb	$3000
Monthly ARPU	$50

As illustrated in the table above, CPRIAdvisor can save mobile operators more than 50% in both maintenance time and cost, ultimately providing improved mobile services and user experience.

Conclusion

The radio access network continues to evolve and expand, taking advantage of fiber technology in the front-haul, centralizing signal processing, and distributing remote radios.

This new topology improves network operations, but the exponential demand of mobile users for bandwidth capacity creates the need to augment radio technology with additional signal carriers and multiple antennas to transmit and receive traffic. All of this adds maintenance complexity while increasing exposure to interference, diminishing service quality.

Viavi CPRIAdvisor provides RF visibility of the radio access network, anytime, anywhere. Covering macro-cells, DAS, and CRAN topologies with fiber front-haul, the solution provides continuous insight into mobile service quality through fiber (CPRI/OBSAI link) monitoring and spectrum analysis, and allows proactive maintenance of possible internal interferences (PIM) as well as prompt detection and identification of external interferences. As a result, mobile operators reduce maintenance time and cost, while improving the user experience.

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