LTE Evolved Multimedia Broadcast Multicast Services (eMBMS)

LTE is the technology of choice for mobile operators because it delivers significantly higher bandwidth with the lowest amount of spectral resources.

As LTE gets widely deployed, mobile operators continue to harness its benefits to improve end-user experience and to monetize their investments by improving the use of spectral resources and by offering new and improved services to subscribers at a lower cost.

One feature that greatly enhances user experience and improves spectral efficiency is eMBMS. eMBMS delivers content to multiple users simultaneously with a fraction of the resources required by normal data services. Economies of scale yield a greater value to mobile users who are able to receive rich content, such as video, at a fraction of the cost.

For example, during major sporting events and concerts, instead of a single mobile user receiving related video services at a very high premium and using dedicated resources, eMBMS provide the same video services to multiple users at a much lower cost per user and using the same amount of resources.

Figure 1. Indianapolis 500 car racing — unicast (PDSCH) and broadcast (PMCH)

Architecture

Four main network components collaborate to deliver eMBMS:

- Broadcast multicast service center (BMSC) — located at the core of the network, managing the interface with content providers including billing and the content to be transmitted over the wireless network
- MBMS gateway (MBMS-GW) — a logical element that delivers MBMS traffic using IP-multicast reaching multiple cell sites in a single transmission
- Multi-cell/multicast coordination entity (MCE), responsible for the administration of radio resources for MBMS to all radios that are part of the MBMS service area
- The mobility management entity (MME) that performs the MBMS session control signaling including session start, update, and stop, as well as delivering additional MBMS information to the MCE such as QoS and the MBMS service area

eMBMS provide broadcast multimedia services through the LTE network, combining unicast physical downlink shared channels (PDSCH) and physical multicast channels (PMCH) services in the same LTE frame.

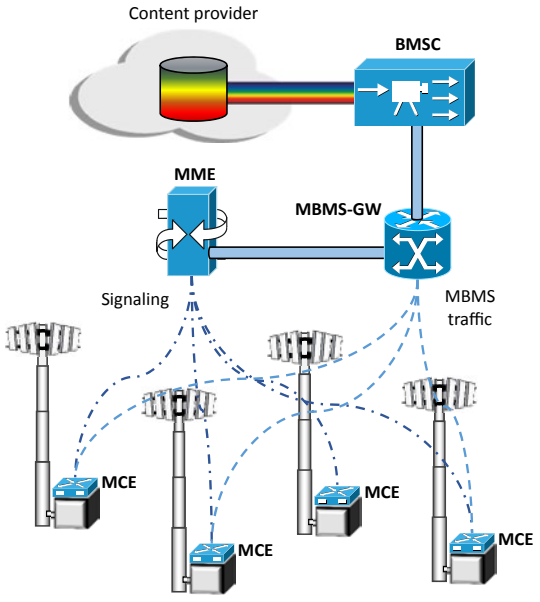

Figure 2. MBMS network architecture

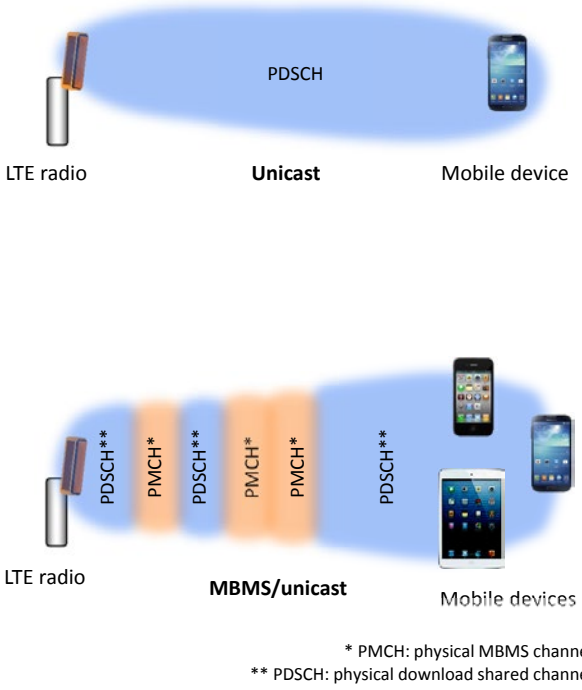

Figure 3. Unicast (PDSCH) and broadcast (PMCH) transmissions

LTE-MBMS radiates the same content to multiple users located within a predefined MBMS service area, letting all the users subscribed to MBMS simultaneously receive the same multimedia content.

To implement eMBMS, features are implemented across almost all the layers from PHY to the core network.

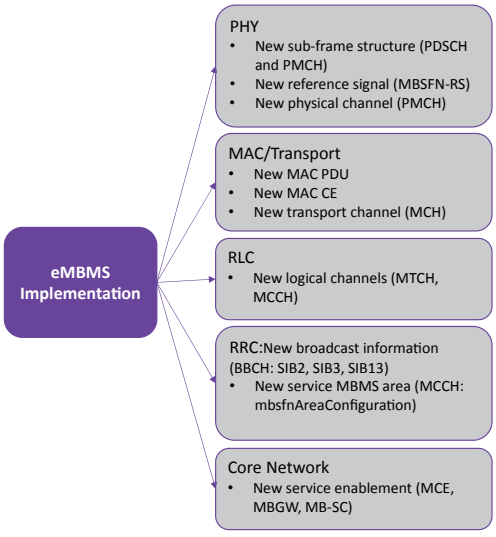

Figure 4. eMBMS implementation across the LTE network

New Channels Introduced in eMBMS

Logical Channels

Provide services for the medium access control (MAC) layer within the LTE protocol structure

Transport Channels

The physical layer transport channels offer information transfer to MAC and higher layers

Physical Channels

Transmission channels that carry user data and control messages

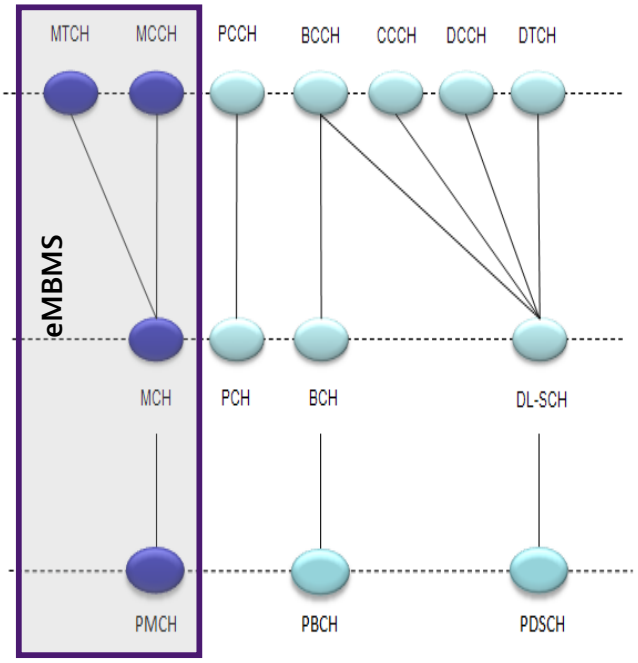

Figure 5. eMBMS channels

MBSFN (MBMS single-frequency network)

One of the most interesting and important characteristics with LTE MBMS is the introduction of MBSFN (MBMS single-frequency network) areas. All cells in such an area transmit the same eMBMS-content in reserved subframes, finely time-synchronized so that the transmission from different cells appears to the receiving UE like multipath from a single cell only. This enables considerable macro-diversity gain at the UE.

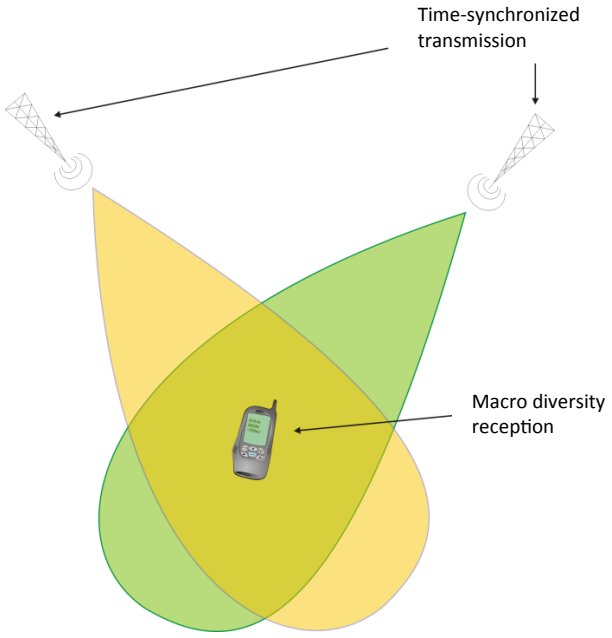

Figure 6. MBSFN advantages

Delivery

Multi-cell eMBMS deployment requires a strict synchronization between participating cells. UE have to achieve a time alignment of less than one extended cyclic prefix (CP), 16.67 µsec, for the signals to be additive.

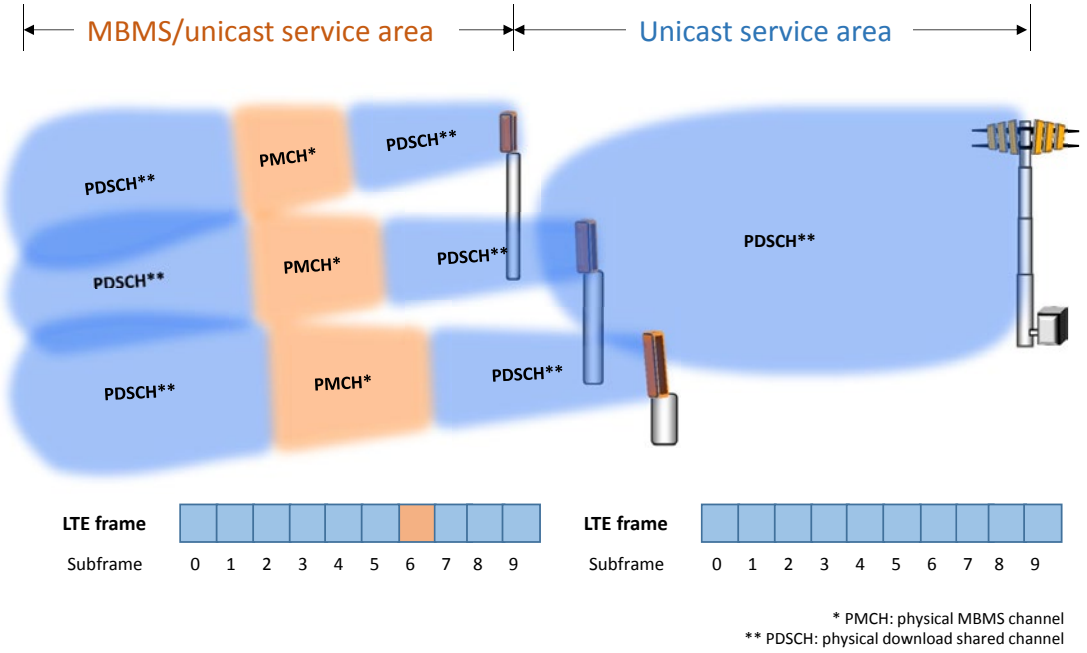

Figure 7. MBMS service areas

This MSFN synchronization area is defined by 3GPP as an area of the network where all radios are synchronized and capable of supporting one or more MBSFN areas, over the same carrier; however, each radio can only serve one MBSFN synchronization area.

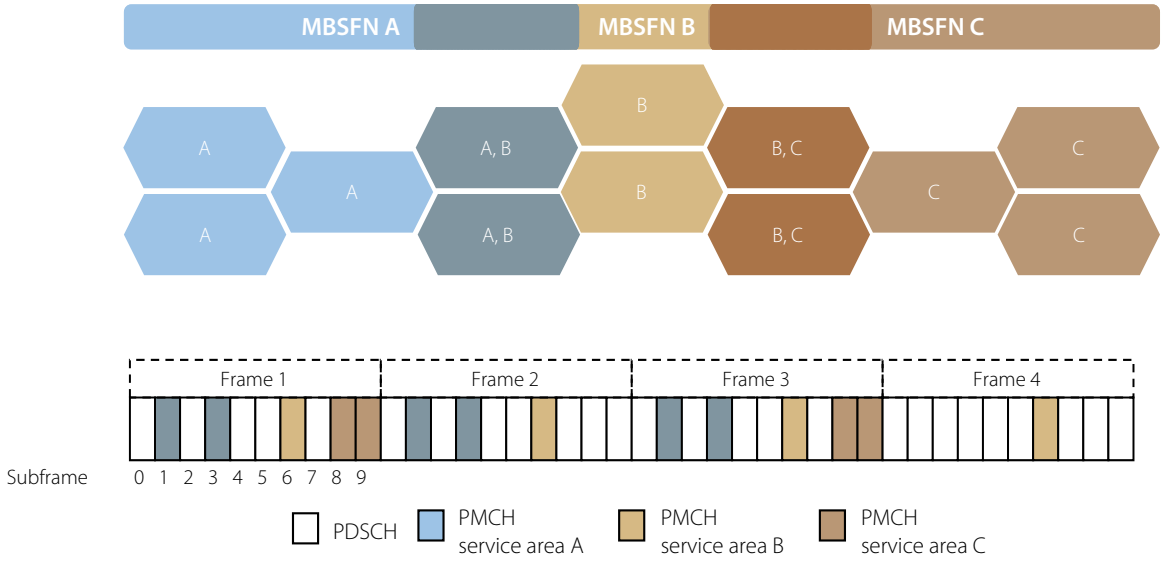

Figure 8. MBMS service areas

MBSFN Allocation

The multicast channels within the same MBSFN area occupy a pattern of LTE sub-frames, not necessarily adjacent in time, indicated by the common subframe allocation (CSA) pattern that is periodically repeated.

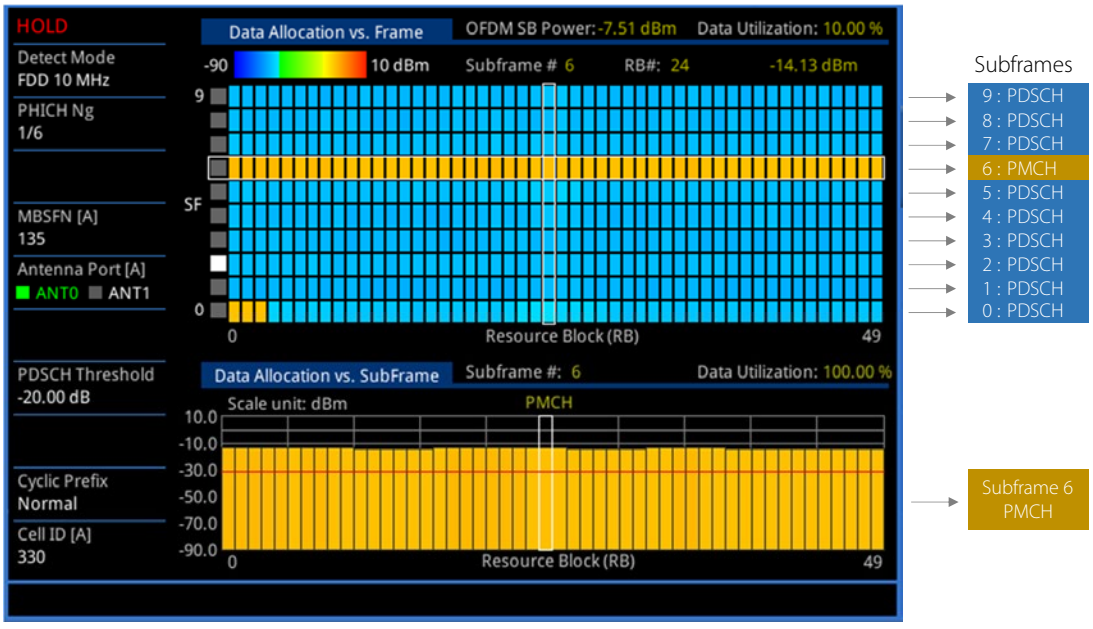

Figure 9. CellAdvisor LTE frame analysis — unicast (PDSCH) and broadcast (MBMS) allocations

Performance

MBMS-SFN services are static and do not vary over time. This provides several benefits, including:

- Reduced interference
- Increased diversity

MBMS-SFN is broadcast by PMCH. This provides the following unique characteristics:

- The PMCH can be transmitted in QPSK, 16 QAM, or 64 QAM
- No transmit diversity (MIMO) scheme is specified
- Layer mapping and pre-coding shall be done assuming a single antenna port and the transmission shall use antenna port 4
- The PMCH can only be transmitted in the MBSFN region of an MBSFN sub-frame
- The PMCH shall use the extended cyclic prefix
- The PMCH schedule cannot be dynamically adjusted by the radio

In the following example, MBMS data is transmitted over service area MSFN 135 on LTE sub-frame 6 and data is transmitted using a QPSK modulation scheme.

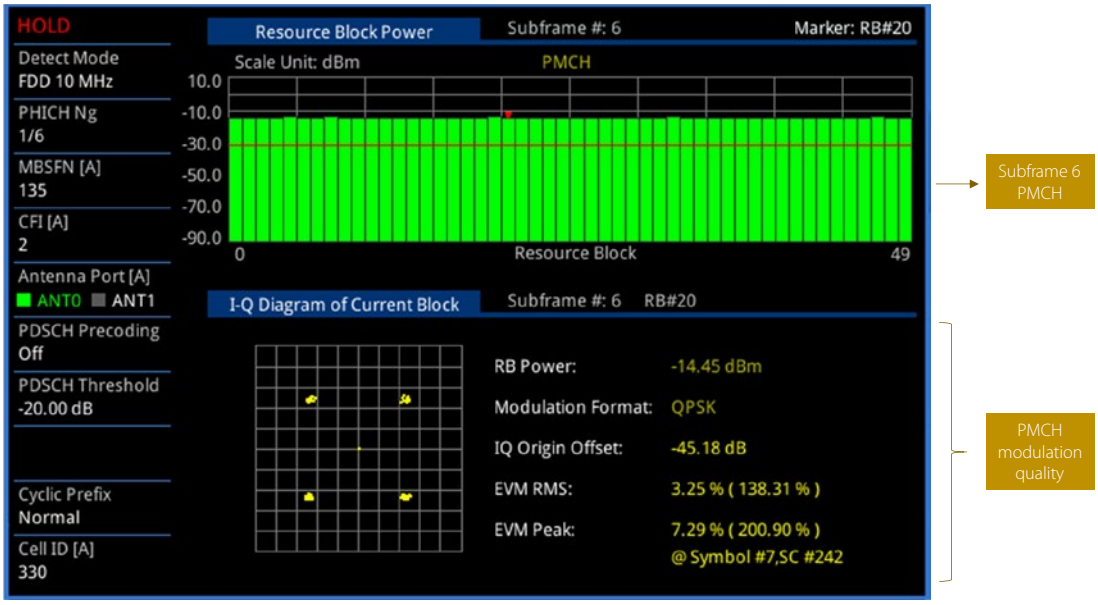

Figure 10. CellAdvisor broadcast (eMBMS) modulation quality

Modulation quality is measured as the level of distortion on the modulated symbols by a metric defined by the standards as error vector magnitude (EVM), which measures the amount of error or distortion the symbols are experiencing at the user device from the ideal position.

PMCH High modulation quality

PMCH Low modulation quality

Figure 11. Broadcast (eMBMS) modulation quality

The PMCH contains the following logical channels:

- Multicast traffic channels (MTCH) — transporting multimedia content
- Multicast control channels (MCCH) — transporting control content such as MBMS sub-frame allocation and modulation scheme for mobile users to properly receive the multimedia content

Since the MBMS transmission serves multiple mobile devices, there is no feedback such as hybrid ARQ and MIMO is not supported. Therefore, the common control pilot signals or reference signals are not delivered as RS0 or RS1 for MIMO 2x, since MIMO is not supported; but logically, the MBMS pilot signal or MBSFN-RS is delivered, per 3GPP, as if it was on antenna 4.

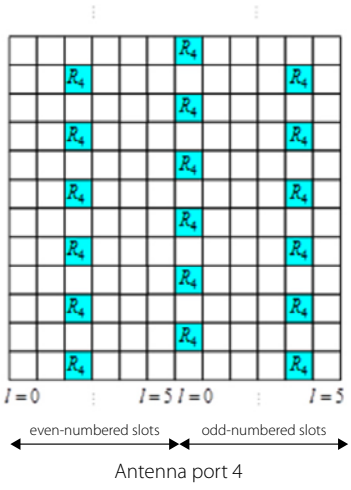

Figure 12. MBMS-SFM reference signal

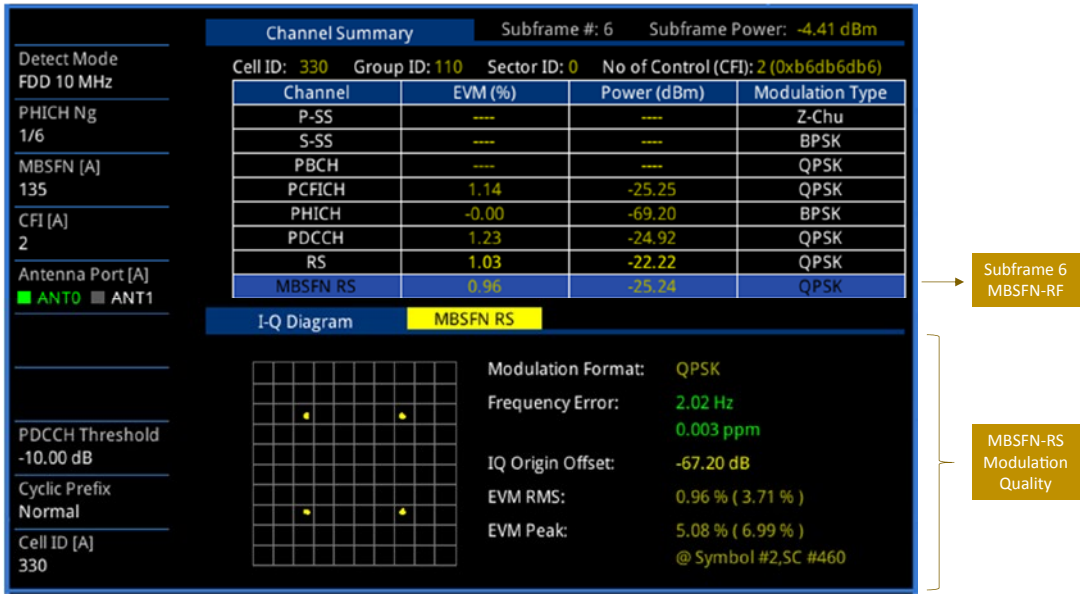

Figure 13. CellAdvisor MBMB SFN reference signal (MBSFN RS)

eMBMS Deployment and Operational Challenges

eMBMS are unacknowledged, which means there is no feedback from the user device that could be used to estimate the quality of eMBMS implicitly. Therefore, it is very challenging for an operator to identify quality issues of eMBMS locally, within a cell or even network wide. At the same time, it is essential for service providers to make sure that they are receiving the true benefits of eMBMS.

For eMBMS to deliver on resource efficiency, multi-cell eMBMS deployment is a must have. Multi-cell EMBMS deployment requires a strict synchronization between the participating cells. UEs have to achieve a time alignment of less than one extended cyclic prefix (CP), 16.67 µsec, for the signals to be additive.

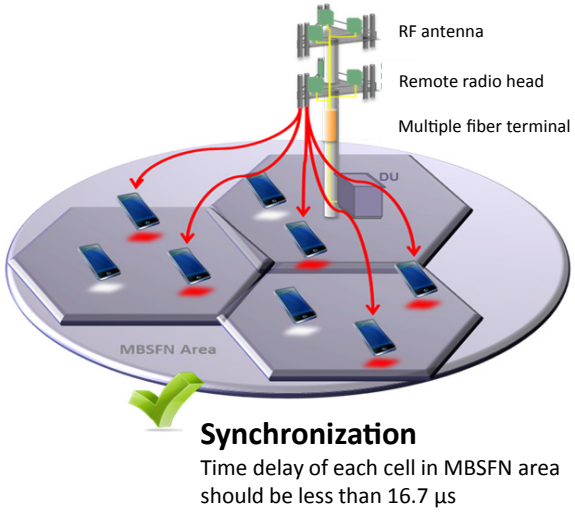

Fig 14 eMBMS synchronization

Additionally, operators need to configure the most optimal value for an MBSFN service area. Optimization entails choosing the maximum MCS that can meet the coverage requirement. Selecting a low MCS for eMBMS data will achieve coverage at the expense of valuable unicast resources. More LTE resources will be reserved for eMBMS traffic than are required, resources that otherwise could be used for unicast traffic.

MCS Index	Modulation Order	Transport Block Size (TBS) Index	TBS (Number of RB 50)
0	2	0	1384
1	2	1	1800
2	2 (QPSK)	2	2216
…	…	…	…
7	2 (QPSK)	7	6200
…	…	…	…
13	4 (16 QAM)	12	12960
…	…	…	…
19	6 (64 QAM)	17	21384
…	…	…	…

Accordingly, sophisticated localized and wide area measurement tools are crucial for successful eMBMS deployment and validation. Operators need to make sure MBSFN areas are created with optimal MCS values and timing synchronization requirements are met. If the MBMS signal coming from multiple eNodeBs belonging to the same MBSFN is not synchronized, diversity gain will not be observed and MBMS SNR will not be optimal.

Viavi has partnered with operators to deliver effective eMBMS validation and optimization solutions. CellAdvisor™ , TrueSite™, and TrueSite Matrix™ provide key insights into eMBMS performance, empowering the operators to take corrective action to optimize MBSFN service area parameters. Viavi eMBMS solutions offer both cell and end-user views on a real-time basis.

CellAdvisor eMBMS Measurements for Conformance Testing

Proper delivery of MBMS relies on the ability to synchronize the transmission from all the sectors in the MBSFN service area in order to create a constructive interference; therefore, it is particularly important to maintain low time alignment error (TAE) among the transmitting sectors.

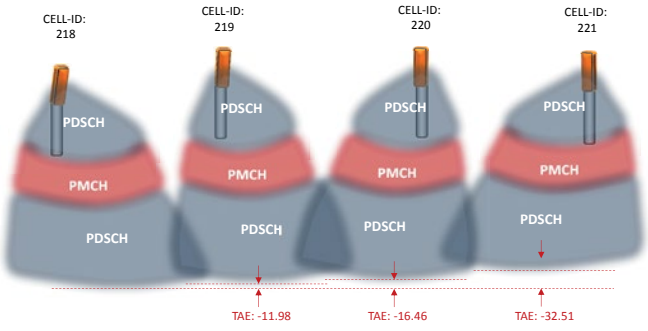

Figure 15. Multi-sector TAE

The following is a measurement technique where the sector identities or physical cell identities (PCI) are set accordingly to the service radios and TAE measurements are performed in PDSCH where each sector transmits its own reference signal.

The synchronization of sectors is measured in terms of TAE with the first PCI as a reference.

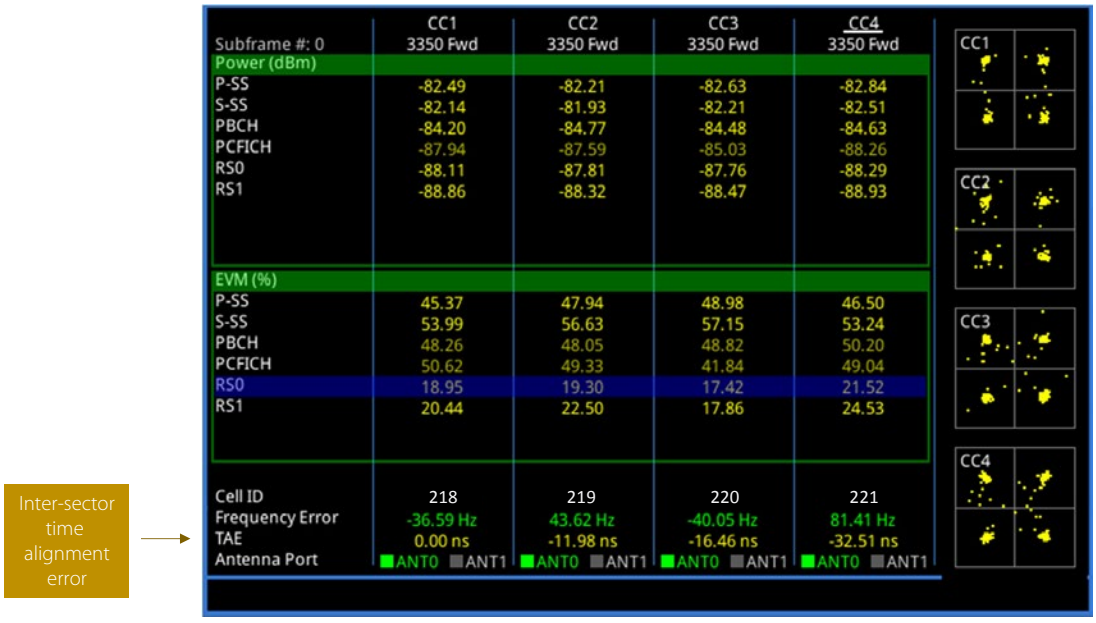

Figure 16. CellAdvisor multi-sector TAE

Figure 17. TAE measurements

Selection of Proper MCS (modulation and coding scheme)

As all cells within an MBSFN area transmit the same information in a time-synchronized fashion, the MCS will be identical. CellAdvisor and TrueSite can help determine whether the selected MCS is able to satisfy the quality requirements in all desired areas. Generally, network operators are too conservative in their selection of MCS and most likely pick QPSK when they should use 16 QAM or even 64 QAM. Consequentially, more resources are used to transmit eMBMS content, impacting spectral efficiency.

CellAdvisor lets operators correlate a modulation scheme and the associated EVM at any point in time to provide insight into the quality of an eMBMS implementation. This empowers the operators to further tweak the MCS configuration to improve user experience and spectral efficiency.

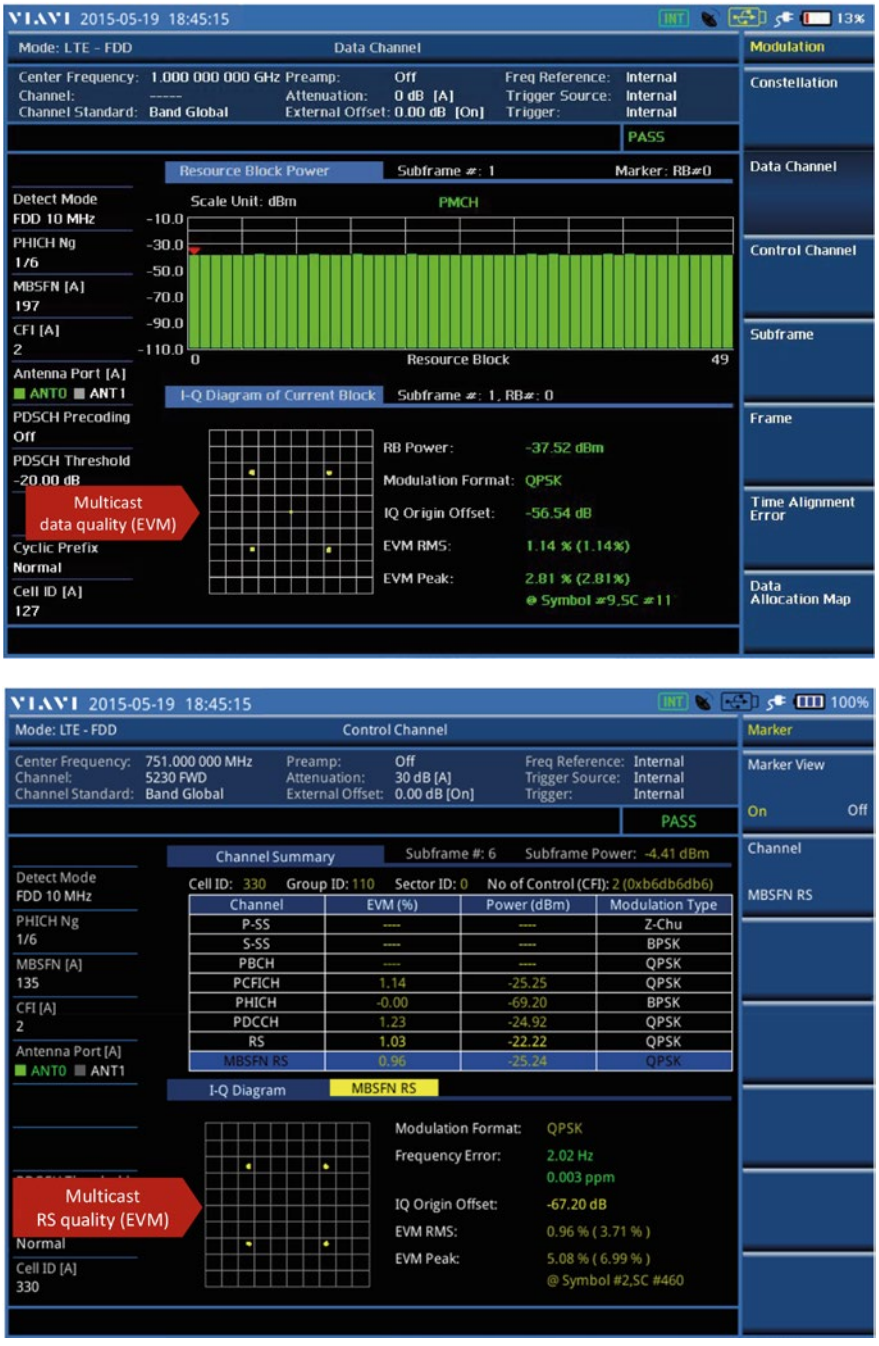

Figure 18. Multicast (MBMS) reference signal and data quality

eMBMS Validation Using TrueSite

To ensure eMBMS are working optimally, it is essential that configuration parameters like MBSFN-area Id of a cell, PMCH setup, and subframe allocation are validated. The Viavi TrueSiteTM solution provides all necessary information about configuration parameters to ensure proper operation and setup. It also provides key KPIs to show the true benefit of eMBMS.

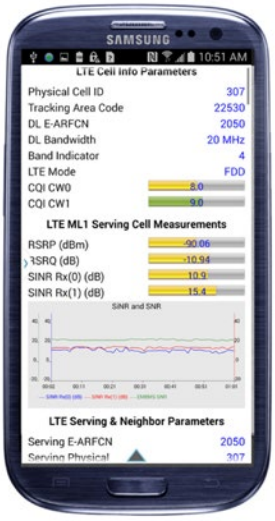

Figure 19. TrueSite for eMBMS

Figure 20 shows LTE eMBMS active bearer list information. The MBFSN Area ID entry confirms that the UE is locked onto the correct network. The Number of Active Bearers entry shows that usually only one is provisioned.

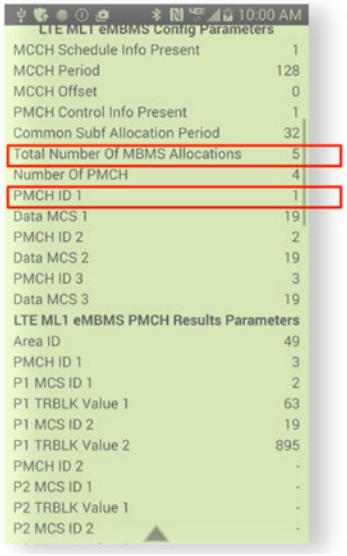

Figure 20. Bearer List information

Figure 21 shows LTE ML1 eMBMS configuration parameters. In the Number of PMCH entry, the number of physical multicast channels confirms the number of multicast video/audio/data multicasts that are being transmitted by the network. In this example, four video channels are being simultaneously multicast through the eMBMS network. The Data MCS entry shows that the modulation and coding scheme is set and fixed by the network throughout the eMBMS transmission, unlike unicast traffic where the UE and network are constantly adjusting this based on the RF environment.

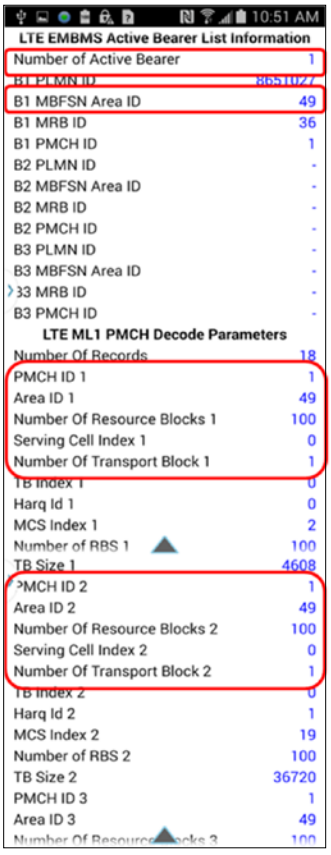

Figure 21. eMBMS configuration parameters

Figure 22 shows LTE ML1 eMBMS PMCH result parameters. The Area ID entry is the MBSFN ID and is just a confirmation that the configuration MBSFN matches what is being decoded by the UE. The P1 MCS ID 2 entry is the Data MCS and as such will be the same as what was set by the network and transmitted in the network configuration.

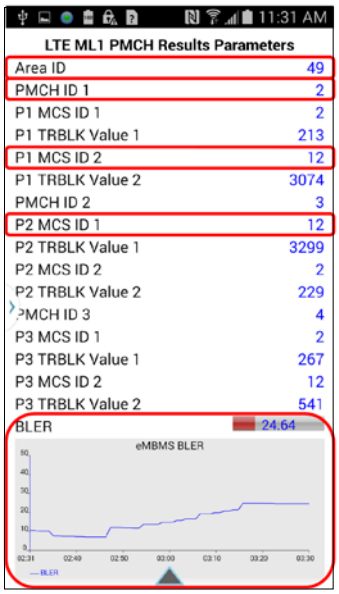

Figure 22. eMBMS PMCH Result Parameters

Figure 23 shows LTE ML1 eMBMS PMCH decode parameters. There are a number of KPIs that are repeated from other sections here but the unique one to monitor is the number of resource blocks. This also is fixed by the network and is used to confirm the correct configuration is being received by UE.

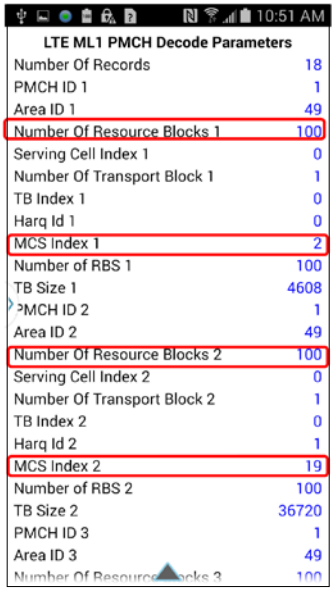

Figure 23. eMBMS PMCH Decode Parameters

Figure 24 shows LTE ML1 PMCH result parameters. TrueSite provides the flexibility to customize KPI charts, eMBMS SNR and unicast SiNR can be plotted in a single graph to see the gain eMBMS offers vs. unicast. This single KPI, eMBMS SNR, along with BLER is the most important KPI to monitor eMBMS performance and to ensure that the eMBMS are at least as good, if not better, than unicast SiNR.

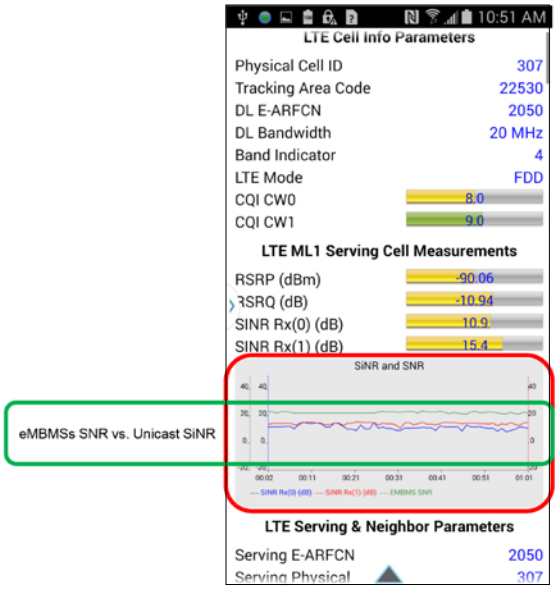

Figure 24. eMBMS KPIs

Summary

In summary, RANAdvisor Truesite™ and CellAdvisor eMBMS features help operators efficiently verify, optimize, and troubleshoot eMBMS. The following table gives a high-level view of eMBMS parameters and supported KPIs.

Measurements	RANAdvisor TrueSite	CellAdvisor	Comments
MBSFN Area ID, MBSFN reference signal power level and modulation quality (EVM)		■	Validate deployment configurations and coverage of eMBMS signal
PMCH ID, MRB ID, MCCH schedule information, period, and offset	■		Validate signal is present when it is meant to be
PMCH sub-frame verification, transmission power level, and modulation quality (EVM)		■	Verificate signal power level and signal quality or modulation distortions
eMBMS SNR and BLER	■		Compare to unicast SiNR vs. eMBMS SNR to determine MBSFN gain; ensure MCS configuration is appropriate for the MBSFN area
Frame and sub-frame resource utilization		■	Ensure target cell is broadcasting eMBMS data traffic
MAC and RLC statistics · Data PDU received, Dropped Data PDU, Bytes received, Calculated Throughput	■		Validate performance of upper layers carrying the eMBMS channel: throughput, channel losses

References

- 3GPP 23.246 Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Architecture and Functional Description
- 3GPP 36.211 Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation
- 3GPP 36.300 Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall Description; Stage 2

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