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Offloading Data Using Unlicensed LTE

(CBRS)

A Technical Paper prepared for SCTE•ISBE by

Loay Kreishan
Principal Mobile Engineer II
Charter Communications
6380 S Fiddler's Green Circle, Greenwood Village, CO 80111
303-793-4489
Loay.Kreishan@Charter.com

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Introduction

Multiple System Operators, MSOs, are capitalizing on new revenue streams by providing mobile services to their customer segment through mobile virtual network operators, MVNOs. MSOs are motivated to offload mobile data onto their own wireless infrastructure in order to reduce mobile data cost and improve user experience. MSOs can utilize Wi-Fi and LTE networks operating on spectrum bands like 3.5GHz Citizens Broadband Radio Service (CBRS), while keeping users registered with the MNO network to take advantage of broad coverage.

To this end, some MSOs are investigating using dual credential user equipment (UE). A UE with two subscriber identity modules (SIM) enables it to simultaneously stay attached to two networks. Dual SIM dual standby (DSDS) handsets are widely available in the market particularly in Asia.

This does not come without obstacles. The main challenge in the existing DSDS UE implementation is that it requires intervention on the part of the subscriber to designate one network for data and one for voice. The existing DSDS UE functions under the assumption that the subscriber has full control to select which networks will be suitable for data.

Because both networks' overlap, there is no need for the UE to know when it is within coverages and which network to use for data. Put simply, the devices don't need to be smarter in this area.

The standard DSDS implementation does not meet the MSO offloading requirements because the two networks' do not overlap.

This paper first describes how the solution of using DSDS UE meets the main requirements of offloading data. The existing DSDS UE needs enhancements to seamlessly select a designated data network and dynamically switch data path between networks when available.

Then the paper depicts an improved DSDS solution, which is called dynamic DSDS (D-DSDS) in this paper, that lifts the burden of intervention from the subscriber and elevates his experience. Last, some promising D-DSDS results from early trials is shared that indicates a D-DSDS solution will soon become a reality.

Data Offloading for MVNOs

For MSOs running MVNOs, one of the main sources of lowering data cost comes from offloading to less expensive, and sometimes free, sources of access networks like Wi-Fi. Along with the introduction of multiple licensed and unlicensed spectra like 3.5GHz CBRS spectrum came the opportunity to provide low cost mobile and fixed wireless broadband. MSOs are capitalizing on the implementation of these small cell CBRS networks to lower their MVNO data costs.

Early stages of deploying CBRS small cell networks will primarily be focused on densely populated, high traffic areas. This will leave the remaining uncovered areas, to be serviced by macro cells. Macro cells coverage can be provided by existing mobile network operators MNOs. The overall view of the coverage map will resemble a small spotted coverage area of CBRS networks (Figure 1). MVNOs using small cell will still depend on MNOs' network to provide complete, continuous coverage for their subscribers.

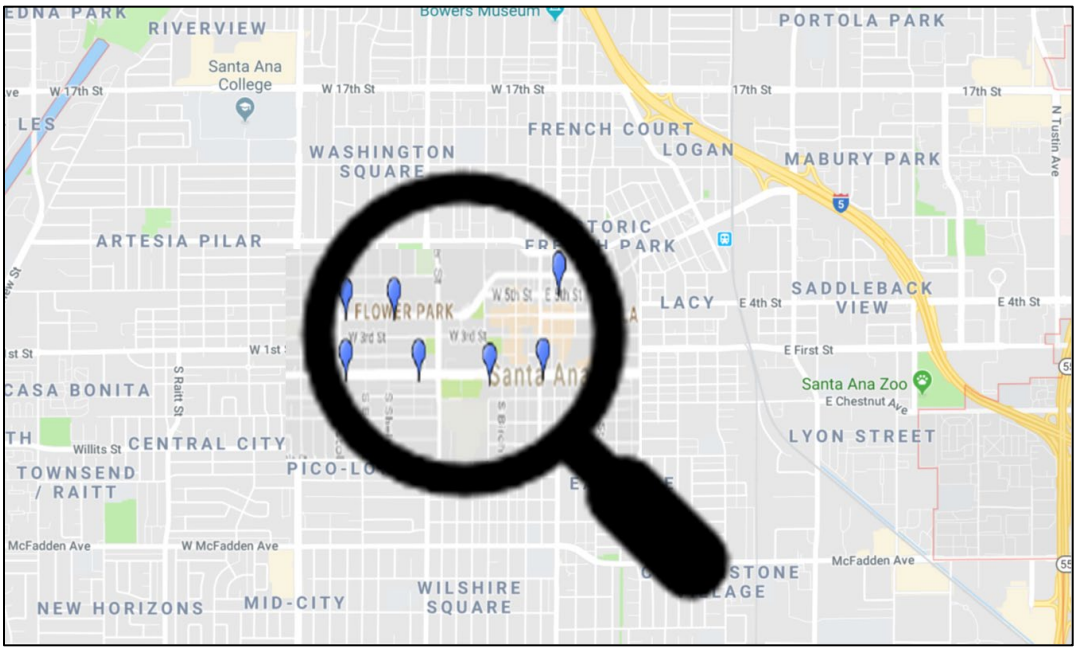

Figure 1 - Small Cell Coverage

There is no benefit for offloading voice services onto MSO network due to patchy nature of CBRS small cell network and voice type services are likely to be disrupted due to potential subscriber mobility. That is the MSO network will only support data services (D) for data offload only. The primary SIM network associated to the MNO will be used for voice and data services (V+D) and will be the only source for providing voice service (Figure 2).

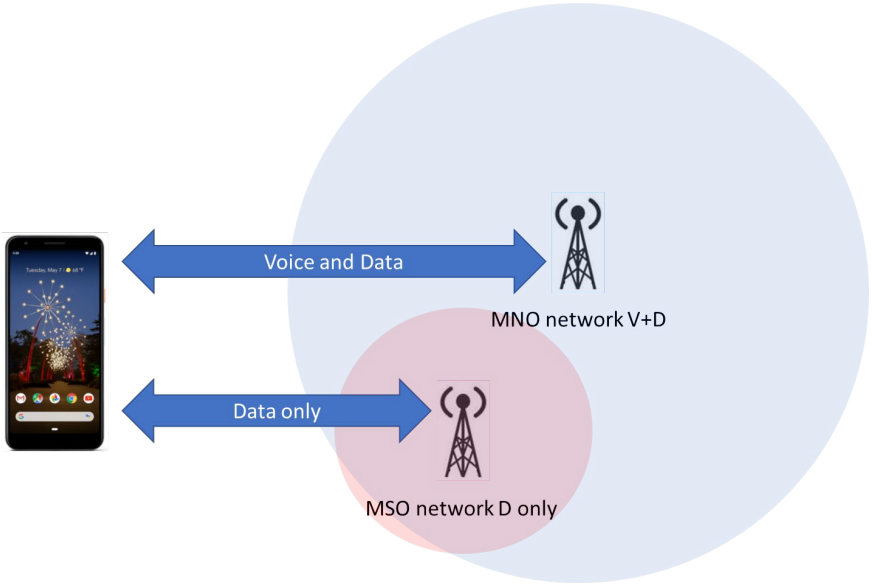

Figure 2 - Voice and Data networks

This requires an active UE that can connect to multiple networks and implementing policy for selecting an offloading network. Connecting to multiple networks raises the issues of session continuity and user experience. Since offloading to Wi-Fi, it has been a challenge to move between multiple independent networks while maintaining session connectivity and providing non-interrupted data services.

How Conventional DSDS Solutions are not Adequate

To solve this challenge, some MSOs have considered a variety of solutions which include:

1. Network sharing
2. Roaming
3. Smart SIM
4. Standard DSDS handsets

Of these solutions that achieve network selection, they do not support the required offloading behavior. The main requirements of successful offloading include:

1. Supports multiple offload networks. Multiple networks (carrier profiles) that support data can be provisioned on the UE.
2. The UE will select available network based on priority and session transition threshold provided by the carrier.
3. Seamless and dynamic data plane transition without user intervention.
4. Maintain user experience. The user's experience will be the same or better than with a single SIM device.
5. MSO offload networks will be used to support only data services and not voice services. Voice services shall use the primary network for voice.
6. Data offload shall not depend on integration between MSO and MNO networks, carriers' configuration, or user equipment configuration through a user interface.

The available solutions fall short of meeting the requirements. The requirements mentioned above for offloading are not met for the following reasons:

1. Network sharing and roaming require support from the MNO to enable certain interfaces between the two networks. This will limit the capability of carrier, MVNO or MSO to dynamically select the desired network based on location.
2. Additionally, roaming requires the carrier to have all services available including voice infrastructure which will increase the cost of the offload network.
3. Solutions stated above assume that either both provisioned networks fully overlap, as in the case of DSDS, or they do not overlap at all, as in the case of roaming. In the case of offload, it may include both scenarios as depicted in Figure 1.
4. In the case of existing DSDS implementation, the user is requested to select the primary and secondary networks for voice and data. The selection is fixed and requires user intervention to change it. User intervention limits the carrier from selecting multiple offload networks.
5. The selection of networks in DSDS is static based on user choices. Changing the default network for data because of availability, quality or cost is not possible.
6. In the case of existing DSDS, the selected primary data network will always support voice services. This scenario may not be desirable if the secondary network used for offloading is out of reach.

The standard DSDS device/UE capabilities in the market today meet most but not all the offloading requirements. There is always room for improvement. To this end, Spectrum Mobile's engineering team has worked with handset OEMs to provide an enhanced version of the DSDS that more comprehensively meets all offload requirements. We will reference this advancement of DSDS as Dynamic DSDS (D-DSDS).

The Dynamic DSDS (D-DSDS) Mode

D-DSDS UE takes advantage of chipset features that provide dynamic switching. In this case each network will have a registered packet data network (PDN), but only one PDN will be used for data, namely the primary network, at a given time as depicted in Figure 3

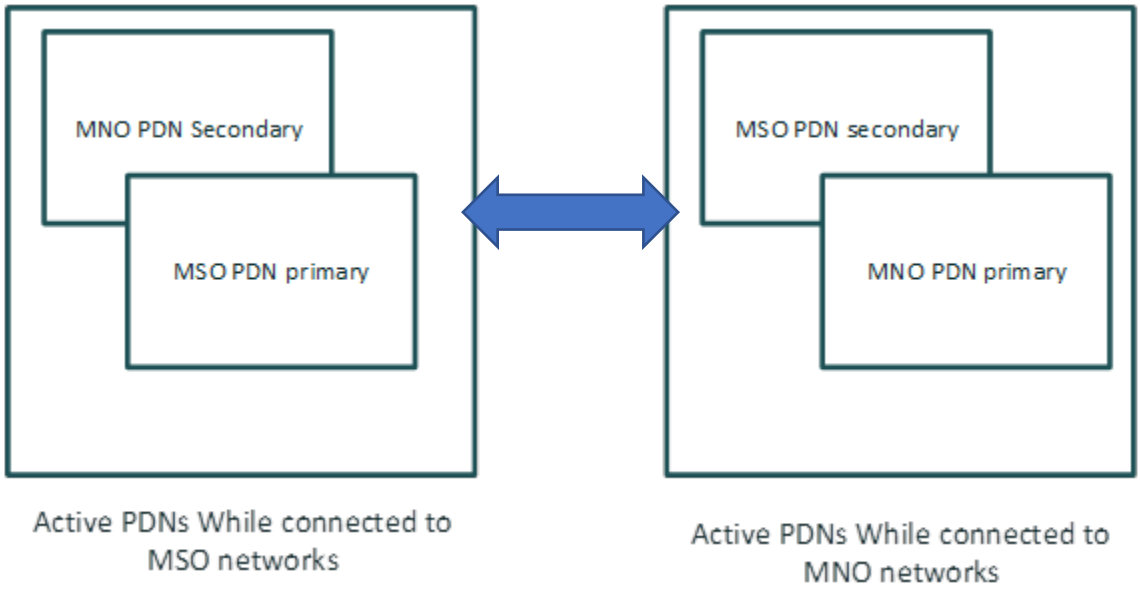

Figure 3 - PDN Status During Mobility Between MSO network and MNO Network

When the UE transitions to the MSO network coverage, it will continue tuning to the MNO network to listen to its paging window. If there is a page destined for the UE, it will check the invite message to determine if there are voice services (e.g. MMS, SMS or VoLTE) session or data session. The UE will switch to the MNO network only if there is a voice service session waiting on the MNO network. At that time, the active PDN will be the MSO PDN offload network. If the invite message has a data session on the MNO network, and the UE is not idle on the MSO networks, then the UE will not switch to the MNO network and will keep the MSO PDN as the active PDN.

Another enhancement is to enable UE to seamlessly switch between primary and secondary networks. While the D-DSDS UE follows the 3GPP technical specifications for handover and mobility within a network, it has intelligence and capability to select and connect to the appropriate data network based on location and network selection thresholds provided by the MSO carriers.

Location will provide the UE with information about possibility of available networks and when to start the process of searching and connecting to the MSO network. A geolocation function, part of the connection manager, will process the information provided to the handset and select the best network for the current location and the appropriate time to transition between networks.

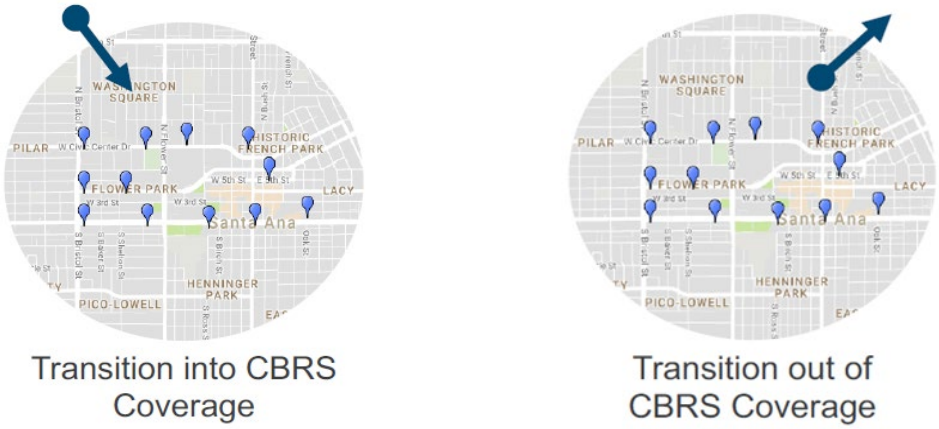

Figure 4 - Geolocation Function

A major benefit of the geolocation function is to improve the percentage of offloading by minimizing the scanning interval time. Minimizing power drainage from unnecessary scanning and associating to multiple small cell networks means resources are utilized more efficiently.

Network transitioning thresholds are an important factor as well. The standard DSDS has network-independent transitioning thresholds provided by each network and used for events related to mobility for that network. This is true for the D-DSDS UE, but there are additional set of network thresholds that facilitate seamless transitioning between networks. These thresholds are used to decide when and which network to use for data offloading.

The following table lists available network thresholds used by the UE to determine which network to connect to and designating the primary PDN for initiating data session transition. Key threshold values include reference signal received power (RSRP) and average time to trigger (TTT).

Table 1 – Network Thresholds

Threshold	Description
DATA_HANDIN_CONNECT ED_RSRP	Average power value of sector/site
DATA_HANDIN_CONNECT ED_RSRQ	Average signal Received Quality sector/site
DATA_HAND OUT_IDLE_RSRP	Average power value of sector/site
DATA_HAND OUT_IDLE_RSRQ	Average signal Received Quality sector/site
DATA_HAND OUT_CONNECTED_RSRP	Average power value of sector/site
DATA_HAND OUT_CONNECTED_RSRQ	Average signal Received Quality sector/site
Average BLERBER/Frequency (MSO, MNO)	Average Block error and bit error rates when connected to MSO and MNO network
Average Time to Trigger (TTT) value	Time duration required for power values of MSO should be higher than power values of MNO (depends on the direction of handoff)

Unlike the standard DSDS, the D-DSDS handset does not require any user intervention to select and connect to the desired offload network. To the user, the device is still connected to the carrier or service provider network, and more importantly, data services are available and not disrupted. To this extent the user does not need to be concerned with the offload network.

Moreover, the D-DSDS handset will not render any information regarding the offload network. This includes a dedicated received signal strength indicator known as signal bars, network name, network selection option and configuration information of the offload network. This is because the offload network will be totally seamless to the subscriber. The subscriber doesn't need to be concerned with the offload network.

In the case with voice services, the UE will transition to the MNO network to establish the voice session, simultaneously switching the active PDN to MNO PDN. When the voice service is terminated, the UE will revert to the offload network if location and key performance indicators for transition are met. For SMS/MMS, the MNO network will provide these services. The handset will not switch the PDN to the MNO network when receiving invite for SMS services. The UE will be able to receive the SMS content without switching.

Initial Performance Experiments

The first version of the D-DSDS has been used in trials and shows promising results. Vital services and applications were tested implementing D-DSDS during mobility between networks. Among the services tested were voice calls and video streaming. As to be expected, all services performed excellently in stationary, low mobility and performed less than expected during high mobility between networks due to delay. In the cases of high mobility, we see some impact, but results are still within the good to satisfactory range.

Voice: results for testing voice were very good at low and high mobility Video streaming: results for testing video streaming were not affected due to buffering. Although service was not interrupted during high mobility, the network transition was noticeable to the subscriber during high mobility.

SMS/MMS: results were very good during mobility and subscriber did not notice any change in service.

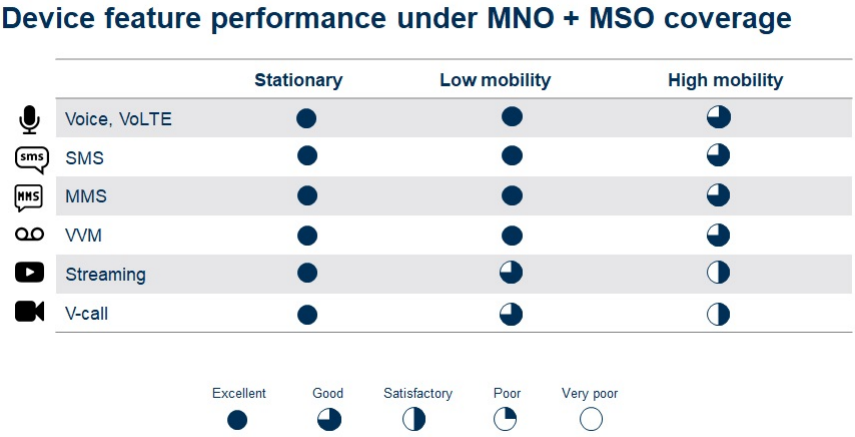

Figure 5 - Initial Test Results

The degradation in service during low and high mobility was due to network transitioning time to switch between PDNs. Although we did not notice any interruption with service, the transition was affecting the service during high mobility.

We think a session continuity solution will reserve the service and allow the running applications to be isolated from the effect of network transitioning.

Future Work

Session continuity and user experience are important performance measurements for successful data offloading. To enhance session continuity and improve user experience a multipath solution like link aggregation will be introduced to the D-DSDS. This important enhancement will allow to unify the user experience when transitioning between available networks MNO, MSO and Wi-Fi.

Link aggregation will utilize a virtual tunnel to provide a single IP address and a virtual gateway IP address for all layer 7 applications, regardless of the network or medium used. Applications will use the virtual IP and the virtual gateway to reach the internet.

Link aggregation will maintain session continuity by providing alternative paths for packets when one path is blocked. It also can provide redundant packet transmission through multiple paths.

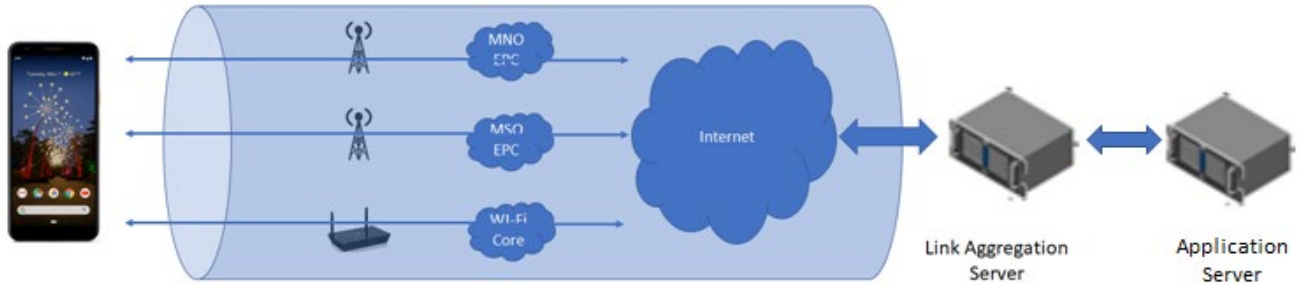

Figure 6 - Link Aggregation

Conclusion

MNOs and MVNOs everywhere are trying to overcome the ever-increasing demand for data while lowering the data cost by providing multiple options for offloading. Current DSDS solutions are missing the mark, and a more dynamic DSDS is on the horizon to enhance connectivity while slashing the costs. Still in its early stages, D-DSDS handsets introduce promising features that are valuable to operators providing mobile data services, private LTE networks or offloading data services alike. During limited trials, most test results have exceeded expectations.

We anticipate more work to be completed on the D-DSDS handset which includes improvements and new features to be added soon.

Abbreviations

3GPP	Third Generation Partnership Project
CBRS	Citizen Broadband Radio Service
D-DSDS	Dynamic Dual SIM Dual Standby
DDS	dynamic data switching
DSDS	Dual SIM Dual Standby
GSMA	Global System for Mobile Communications
MNO	Mobile Network Operator
MSO	Multiple System Operator
MVNO	Mobile Virtual Network Operator
OEM	Original Equipment Manufacturer
PDN	Packet Data Network
RSRP	reference signal received power
RSSI	received signal strength indicator
SIM	Subscriber Identity Module
TTT	time to trigger
UE	user equipment

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