XipNet

Case Study

Enhancing MNO Voice Service Quality over Starlink LEO Service Using XipNet Multi-Orbit SD-WAN

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XipNet Proprietary

Introduction

A major Mobile Network Operator (MNO) deployed mobile service units equipped with Starlink satellite terminals to deliver mobile voice and data services in remote areas with no terrestrial backhaul. The initiative aimed to expand coverage reach and operational responsiveness in disaster recovery, emergency response, and underserved geographies.

Challenge

The MNO's mobile unit needed reliable backhaul to deliver core voice services in regions where no traditional coverage existed. Starlink service was chosen for its promise of high bandwidth and low latency compared to traditional satellite options.

Starlink offered a fast and easy to deploy solution, with interconnect to the MNO's existing L3 security gateway via the Internet. The solution offered high throughput and very low latency compared to traditional GEO satellites.

The Low Earth Orbit (LEO) network's inherently dynamic, sometimes congested behavior and frequently lossy properties led to periodic and often severe voice service degradation and interruptions.

Key Challenges:

- **Time pressure,** to roll out solutions without going through lengthy MNO L2 interconnect projects. This led to the MSN interconnect via L3, over Internet.
- **Call drops** and **service interruptions,** due to congestion**,** lack of QoS and network properties that are vastly different than fiber or other network interconnects.
- **Poor and varying voice quality**, as measured using end to end Synthetic Mean Opinion Score (MOS).
- **Service becomes unusable at times of high congestion.**

Objective

Stabilize and optimize real-time voice communication over L3/Internet connected Starlink backhaul links without deploying expensive fixed infrastructure or compromising mobility.

Solution: XipNet Cloud-based Intelligent SD-WAN Service

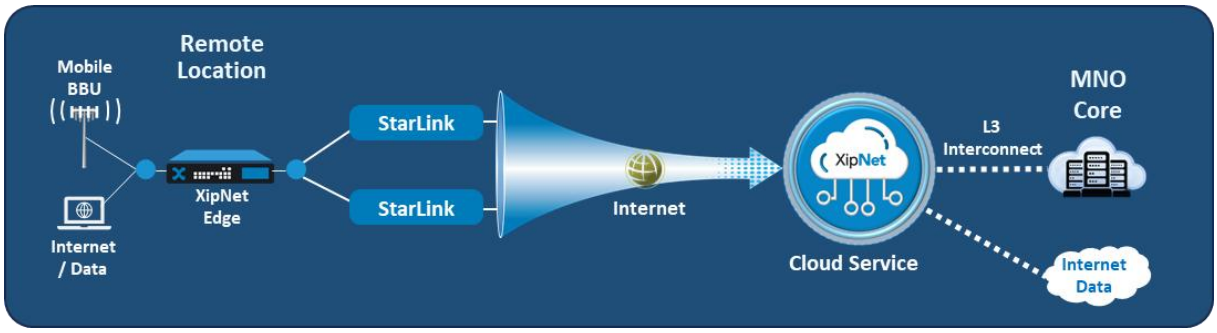
After testing several network performance optimization approaches, the MNO deployed **XipNet's Multi-Orbit/Path SD-WAN service**, selected for its performance and optimization capabilities on constrained high-latency and high-variability links. MNO leveraged XipNet's quick deploy cloud service with LEO-optimized feature set (LEOBoost™) in a low-latency single-hop architecture between the mobile service unit and the MNO's core network.

Enabled Features:

- **Real-time Link Intelligence:** Continuous monitoring of link quality for bandwidth, packet loss and jitter, adapting QoS dynamically as conditions change.
- **Adaptive QoS:** Prioritized latency-sensitive VoIP traffic.
- **Packet Coalescing**: Reduced packet rate (pps) by aggregating small packets.
- **Selective Stream Duplication:** Redundant packet transmission to improve reliability.
- **Link balancing and bonding:** Using multiple Starlink terminals optimally.
- **Intelligent Traffic Steering:** Automatic and Dynamic path selection based on real-time link conditions.
- **Packet re-ordering:** Correcting out of order packets.
- **Seamless Failover:** Maintained uninterrupted sessions during Starlink performance variations or link switchover.

Network Topology

The remote location consists of a XipNet Edge device, one or two Starlink terminals and voice/data devices. Traffic is sent over the Starlink service to the XipNet cloud core system through the internet and then forwarded to the MNO core network for voice services or to the internet for data traffic.



Although XipNet can accommodate many more terminals, in this case only two were used. Testing was performed over both single and dual Starlink terminals.

Test Description

Single or Dual Starlink HP panel connected to WAN side of XipNet Edge device (XH-100), and radio equipment connected to the LAN side of the XipNet Edge device.

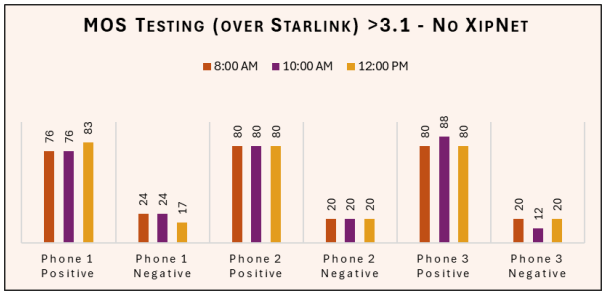
- Four test phones were used
  - One phone was used to generate 60 Mbps UDP traffic in the uplink direction.
  - Three phones ran call testing measuring MOS scores | each phone made 100 phone calls lasting ~1 hour.

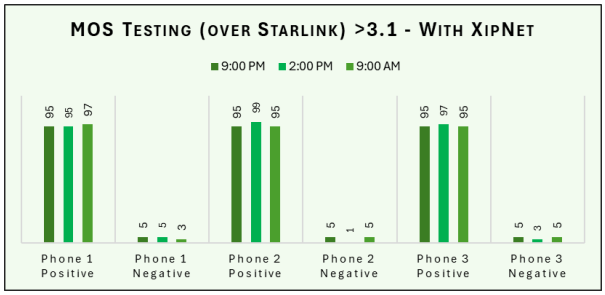
Results with single Starlink Terminal

Metric	No XipNet	With XipNet	Improvement
MOS Score below 3.1	80% Calls	96% Calls	>20% voice quality
MOS Score below 3.5	75% Calls	92% Calls	>30% voice quality
Packets Per Second (pps)	100% baseline	~6% of baseline	94% reduction
Service Availability	Inconsistent	Reliable	High stability
QoS Enforcement	None (Starlink only)	Fully enabled	Application Performance
Percentage of low-quality calls	20% Calls	4% Calls	5x Reduction

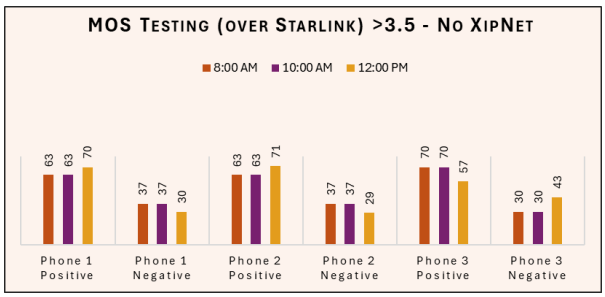
The test results over a single Starlink terminal, shown below, clearly demonstrate that XipNet delivers a substantial improvement in call quality by significantly reducing the incidence of calls with MOS below the industry-acceptable threshold of 3.1.

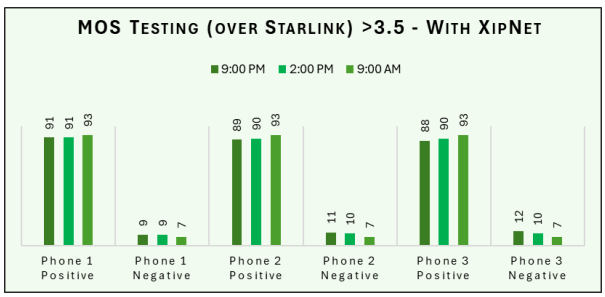
Significantly, the average number of subpar calls dropped from 20 to just 4 - representing a 5x reduction. This outcome underscores XipNet's effectiveness in enhancing overall network performance and ensuring consistently high-quality user experience.





When applying a more stringent benchmark for negative call experiences (MOS below 3.5), XipNet continues to demonstrate significant improvements. The average number of subpar calls is reduced from 35 to 9 - representing a 4x reduction. This further validates XipNet's ability to maintain high voice quality even under tighter performance thresholds.





Results with dual Starlink Terminal

Testing over dual Starlink terminals yielded similar or superior results, with increased enhanced call quality and availability. These improvements were driven by the implementation of stream duplication, Adaptive QoS, link bonding, traffic steering and session persistence mechanisms.

Conclusion

The deployment of XipNet Cloud-Based SD-WAN service transformed the performance of real-time voice services over Starlink LEO backhaul network service. By addressing both service instability, inconsistency and traffic behavior, the MNO achieved:

- **Near-enterprise-grade voice quality in mobile, remote deployments**
- **Substantial reduction of poor-quality call experiences**
- **Increased reliability of mobile service units for operational and emergency use**

Key Takeaway

While Starlink offers a compelling solution for broadband access in remote areas, its current performance presents limitations for real-time voice applications. For mission-critical services, especially those involving voice, MNOs are implementing direct interconnects to Starlink, but this is a time-consuming process. XipNet service enabled the MNO to overcome the core limitations of L3 connectivity to rapidly deliver dependable voice services in the most challenging environments, without engaging in time consuming interconnect projects. The architecture also enables addition of other LEO services like OneWeb and in future Amazon Kuiper, as either backup or concurrent network access paths.