SATHAUL-XE™ TECH BRIEF

ST Engineering

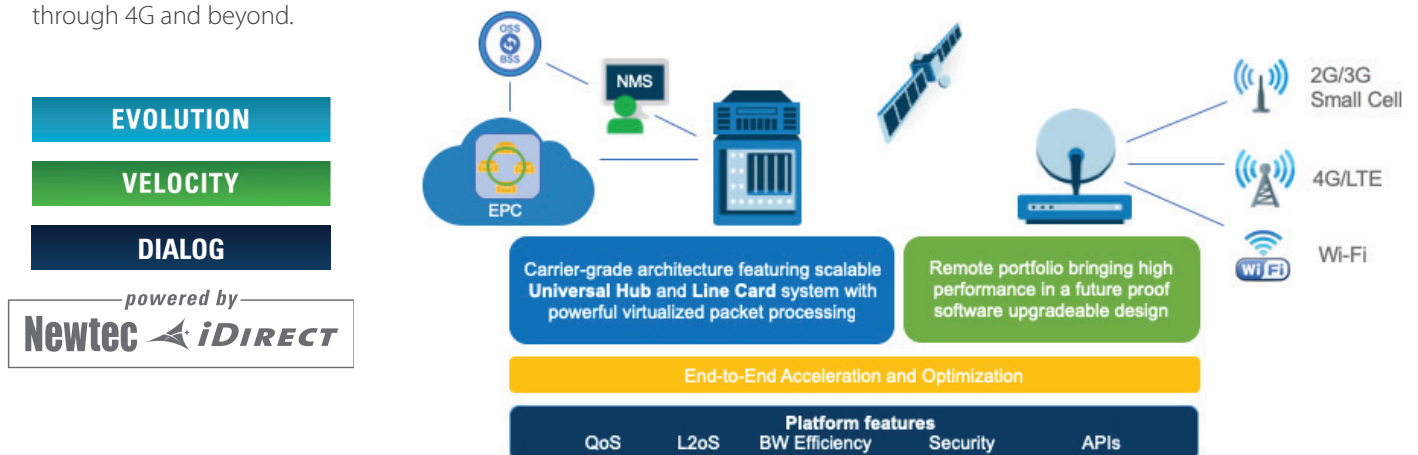## Cellular backhaul over satellite

With the increasing demand for ubiquitous cellular coverage, Mobile Network Operators (MNOs) are facing many challenges delivering services to remote, hard to get areas where terrestrial infrastructure is limited or not available. The other side of the same coin is delivering connectivity where communication is hampered due to disasters and emergencies for first responder teams. Cellular connectivity via satellite is not a new proposition for these scenarios and has come a long way in the past decade. The ability of satellite to provide coverage anywhere on the globe and be deployed quickly has been key to multiple successful deployments, especially in remote areas in Africa, Latin America and Asia.

In general, the role of the satellite in a cellular network is to provide backhaul access from the remote radio access tower back to the core network via the user interface. Obviously there are differences based on the cellular generation deployed (2G, 3G, 4G, etc.) and the particular equipment and vendor implementation. Also, since cellular standards have not been designed for satellite, additional means are required to make the satellite backhaul work transparently and seamlessly as part of the overall network architecture. This means that in order to make CBH over satellite technically and commercially viable, additional traffic handling technologies need to be incorporated in order to overcome the inherent latency and minimize the satellite capacity usage.

ST Engineering iDirect has been a pioneer in providing satellite backhaul solutions to MNOs and Telco's and has followed the progression of the 3GPP standards, providing optimized satellite solutions to various backhaul extension service providers and MNOs across the globe. The SatHaul-XE™ is culmination of many years of optimization technology progression that provides a comprehensive suite of backhaul optimization capabilities over our platform to seamlessly handle all cellular generations through 4G and beyond.

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Overview

SatHaul-XE is a software enabled optimization solution for cell backhaul for 2G/3G and 4G/LTE cellular traffic over satellite, improving the subscriber experience and reducing the satellite capacity cost. The solution leverages iDirect platform traffic engineering capabilities such as QoS and layer 3/layer 2 handling together with WAN optimization software suite that utilize a feature set called Advanced Cellular Compression (ACC), together with IPSEC DoE functionality to address the cellular backhaul market requirements. As an interactive optimization application, it is present on both ends of the satellite link, the hub gateway and the terminal.

The underlying SatHaul-XE software provides reporting in a rich graphical user environment allowing customers to fully visualize the network performance relating to the CBH application. Software updates to the SatHaul-XE system components are completely managed within the SatHaul-XE portal on the hub side virtual appliance, with further improvements planned throughout the coming releases.

Sathaul-XE is a turnkey solution, professionally implemented by iDirect Professional Services and fully supported by iDirect TAC.

On the hub side, the SatHaul-XE is offered as an application on the Dell R640 server, identical to the standard iDirect PP server, or on a FC640 sled that can be installed within the Intelligent Gateway based on the Dell Fx2 chassis. A third option is to run the SatHaul-XE application on a customer-supplied private cloud-native platform of choice.

On the terminal side, SatHaul-XE is offered as an embedded solution utilizing a dedicated software image in the X7-EC router, or as an appliance "companion". The appliance is available as part of a bundle with the iQ 200 Rackmount, or purchased separately for deployment with existing X7 or 9350 modem deployments.

Some of the inherent benefits and features of the SatHaul-XE solution for CBH include:

- Bandwidth reduction of up to 30% for voice and data
- Significant packet-per-second (PPS) reduction of voice calls with no degradation of voice quality
- Flexibility to support multi-service CBH networks (2G, 3G, 4G)
- For LTE networks, data rates in excess of 100 Mbps per site or even per TCP session using GTP acceleration
- For large-scale LTE networks, scaling to 100,000 TCP sessions
- Carrier level redundancy on the hub side, either one-to-one or flexible 1 to N via tunnel mapping
- Support for 4G/LTE IPSEC DOE (Decrypt/Optimize/Encrypt) End-to-End Encryption
- Advanced configuration and management user friendly web-based interface

With the increase in higher data rates and a surge in traffic demands on already congested networks, traffic needs to be handled more efficiently. Intelligent optimization of traffic with the latest technology in acceleration and compression provides maximum throughput and efficiencies.

Advanced Cellular Compression (ACC) feature

Advanced Cellular Compression is available on either layer 2 (using L2oS) or layer 3 utilizing light weight tunneling for management between SatHaul-XE™ endpoints. (Note: IPSEC implementation requires layer 3 over light weight tunnels.)

- **Header Compression**- This feature compresses, coalesces and prioritizes VOIP and UDP packets for significant bandwidth efficiency across multiple streams, also incorporating Robust Header Compression (RoHC). It reduces bandwidth used by voice and other traffic with small packets. This applies to both bi-directional and unidirectional traffic. For VoLTE (Voice over LTE) in which the voice samples are only around 1/3rd of the total traffic, bandwidth can potentially be reduced more than 30% even with IPSEC.
- **Packet Compression**- Uses a packet payload compression technique reducing packet size for fast, lossless compression of individual packets, providing bandwidth savings on the first pass for compressible content.
- **Packet Learning**- Typical cellular data has small traffic with multiple identical headers. The packet learning is a micro-cache technique that uses previously-learned packets to increase compression efficiency even further.
- **Byte Caching**- Cache technique that reduces bandwidth for repeating data can result in significant bandwidth savings for 2nd/3rd pass of data – Up to 80% reduction.
- **Multi-Q Coalescing**- Supports fully independent queue configuration for up to 32 independently configurable coalescing queues available per remote.
- **Integrated QoS**- Advanced Hierarchical QoS with Class Based Weighted Fair Queuing, Prioritization and Guaranteed SLAs.

Table 1: Typical traffic savings for cellular backhaul traffic

Traffic Type	Savings
GSM Voice	20-50%
Edge Data Traffic	15%
3G Voice	25-50%
3G Data (Encrypted)	1-5%
CDMA Voice	40-50%
CDMA Data	15%
4G Voice	25-50%
4G Data	10%

Figures represent typical ranges and may change on traffic patterns.

GTP transparents optimization for LTE

Per 3GPP standards, 4G/LTE user traffic between eNodeB and EPC is encapsulated in GTP (GPRS Transport Protocol) over the S1 interface. This requires special handling to detect and accelerate TCP traffic inside GTP. GTP transparent acceleration is designed for S1 interface in LTE or any other GTPv1-U in GSM/UMTS to ensure that TCP can achieve LTE level performance over the satellite backhaul link transparently. In addition, it optionally supports 3GPP compliant end-to-end IPSEC solution to ensure communications security.

The optimization engine also performs header compression on all the protocol layers being transported (i.e. TCP/IP/GTP/UDP/ESP/IP or RTP/IP/GTP/UDP/ESP/IP etc.) and payload compression of the LTE traffic payload if not already compressed. TCP acceleration using IPv6 transport over GTP is supported as well. Other specific optimization features of the TCP for CBH traffic involve using Selective NACKs (SNACKs) that makes the link much more tolerant for packet loss. Even with packet loss rates as high as 10% the throughput of a link can be maintained at a few Mbit/s whereas it drops close to a few kbit/s without this feature. A final benefit is a reduction, by a factor of five, in the volume of traffic used in the reverse direction to send ACKs, due to the local ACK spoofing performed.

IPSec

Both 2G and 3G cellular networks benefit from inherent encryption of end-user traffic from the handset to the Base Station Controller (BSC) and the Radio Network Controller (RNC) respectively. In 4G LTE, with no radio control node in the User Plane, there is no native encryption of traffic. To remedy this, 3GPP recommends the use of IPSec encryption from the eNodeB to the Security Gateway (SeGW) within the MNO's Core Network.

For networks using LTE backhaul over satellite, where it is necessary to implement features such as TCP Acceleration within the GTP tunnel of the S1 interface to intercept S1 traffic, this presents a challenge. In the SatHaul-XE™ implementation, the IPSec tunnel between the eNodeB and the SeGW is intercepted at both ends of the satellite link, to perform the TCP Acceleration and other optimization features. The de-encryption and re-encryption occurs on a dedicated CPU that is separate from the modem. This eliminates any traffic exposure without affecting modem performance, while maintaining all the optimization eatures on the S1 traffic.

IPSec is implemented with RFC-4303 ESP using tunnel mode between SatHaul-XE end points. Authentication Exchange uses IKEv2 and can be accomplished with public-key certificates (X.509) signatures or Shared secrets. Encryption is done with AES-256 (256 bit AES-CBC, 256 bit AES-GCM with 64 bit ICV) with Integrity of SHA256/SHA2_256 or higher and Diffie Hellman group 15 or higher. Re-keying of IPsec SAs and IKE SAs is supported with intervals of 1 hour or more.

Currently the implementation supports manual configuration of keys. X.509 certificate management requires reliance on an externally managed PKI (Public Key Infrastructure) system. The PKI can be standard X.509 system or open source based to create a CA (Certificate Authority) that will sign host certificates and keys that get installed on SatHaul-XE. In a peer to peer environment, a unique IPSec tunnel per user can be created for a defined unique IP or IP subnet, for up to 250 tunnels per device (the actual limit is higher). Tunnels from dynamic IPs are supported, as well as tunnels created over NAT networks (where the source IP changes).

Management- configuration and monitoring

SatHaul-XE contains a web user interface that allows a user to both configure and monitor GTP optimization and other optimization parameters from a single browser. SatHaul-XE sites can be configured to report all monitoring data to one or more external sites using the collected protocol.

Network operators have several choices for stats collection/storage/visualization:
- All SatHaul-XE sites can collect, store and visualize monitoring data from multiple other sites.
- An operator-managed collected daemon can collect and store SatHaul-XE monitoring data in RRD databases and graphing can be performed by RRDTOOL.
- SatHaul-XE contains SNMP agents with some monitoring (but no configuration) capabilities.
- SatHaul-XE appliances expose a NetConf-over-HTTP configuration and control interface for integration with third-party software. In addition to the collected data provider and SNMP interface described above, third-party monitoring software can also access health and performance data via a REST-like interface that provides historical querying, multiple output data formats and low-level analysis.

Technical Implementation

SatHaul-XE is deployed both on the remote side supporting multiple user CBH sessions and on the hub gateway side to support aggregate CBH traffic from multiple sites. Per the diagram below, there are multiple implementation options available in terms of hub and remote equipment, layer 2 or layer 3 networking, use cases and configuration options.

Note- SatHaul-XE initial installations and deployments are performed by iDirect Professional Services. This is to ensure that installations are completed per the appropriate standard and are supportable during ongoing operation. Once installed, customers will be trained on the operation in a similar fashion to hub installations.

SATHAUL-XE DEPLOYMENT SCENARIOS

1.   Remote side options

For deployments within DVB-S2 networks and aggregate remote throughputs under 70 Mbps, the X7-EC+ SatHaul-XE solution offers an economical single-box solution for 2G/3G and medium density LTE deployments. The SatHaul-XE X7-EC solution features a post-compression 70Mbps rate license, suitable for eFemto, Small-Cell and medium-density Macro deployments.

For aggregate remote throughputs that exceed 100 Mbps with either DVBS2 or DVBS2X networks, the iQ 200 Rackmount+SatHaul-XE Companion bundle is recommended. Utilizing the high-performance and efficiency of L2oS combined with the processing capability of the IQ-200 Rackmount, throughputs up to 200 Mbps are achievable. SatHaul-XE features 50, 100 or 200Mbps incremental licensing.

For scenarios that involve existing satellite remotes or for other deployment requirements, the SatHaul-XE Companion appliance can be paired with X7 or 9350 remotes.

2.   Hub side options

The hub side SatHaul-XE options are designed to complement iDirect hub implementations for either universal hubs that wish to utilize rackmount R640 Dell servers, or for modular iGateway implementations utilizing FC640 sleds in FX2 chassis. Either implementation option requires dedicated hardware for the SatHaul-XE software image. The SatHaul-XE license for the R640 server supports up to 400 Mbps aggregate throughput and the license for the FC640 sled supports up to 1.0 Gbps aggregate post-compression throughputs. Multiple servers/sleds can be combined to achieve even higher throughputs and/or redundancy schemes.

A third option is for other customer-provided private-cloud based platforms provide up to 1.3Gb Licensing per virtual instance. Customers wanting to implement private-cloud implementation are required to work with iDirect Professional services for customized pricing as this option requires special handling by professional service for deployment planning and implementation.

SatHaul-XE packages available for ordering

Embedded Remote Bundles	**BP-X7-EC/CBH-AC:** SatHaul-XE Applications Bundle. Support for 2G/3G/4G with IPSEC. 70Mbps Maximum throughput with 10K Sessions. L2oS or Layer3 Deploy-ments (AC in / 24VDC Out)
	BP-X7-EC/CBH-DC: - Cellular Backhaul Applications Bundle. Support for 2G/3G/4G with IPSEC. 70Mbps Maximum throughput with 10K Sessions. L2oS or Layer3 Deployments. (DC in / 24VDC Out)
Remote Companion Solutions	**BP: SatHaul-XE-Companion-50:** SatHaul-XE CBH Companion Processor. Support for 2G/3G/4G with IPSEC. 50 Mbps Maximum throughput with 10K Sessions. 2nd Box CBH Solution for use with X7, 9350, or IQ Series Remotes (Recommend iGW Hub Side for Scale/Throughput -- REQUIRES EXISTING MODEM or NEW MODEM PURCHASE)
	BP: SatHaul-XE-Companion-100: SatHaul-XE CBH Companion Processor. Support for 2G/3G/4G with IPSEC. 100 Mbps Maximum throughput with 10K Sessions. 2nd Box CBH Solution for use with X7, 9350, or IQ Series Remotes (Recommend iGW Hub Side for Scale/Throughput -- REQUIRES EXISTING MODEM or NEW MODEM PURCHASE)
	BP: SatHaul-XE-Companion-200: SatHaul-XE CBH Companion Processor. Support for 2G/3G/4G with IPSEC. 200 Mbps Maximum throughput with 10K Sessions. 2nd Box CBH Solution for use with X7, 9350, or IQ Series Remotes (Recommend iGW Hub Side for Scale/Throughput -- REQUIRES EXISTING MODEM or NEW MODEM PURCHASE)
	SatHaul-XE-Companion License Upgrade: SatHaul-XE CBH Companion Upgrade from 50 Mbps to 100 Mbps (Deployed Units Only)
	SatHaul-XE-Companion License Upgrade: SatHaul-XE CBH Companion Upgrade from 100 Mbps to 200 Mbps (Deployed Units Only)
IQ-200 + Companion Bundles	**BP-IQ200/CBH-50-AC:** Cellular Backhaul Remote Bundle. Support for 2G/3G/4G with IPSEC. Up to 50 Mbps Maximum CBH throughput with 10K Sessions. Includes iQ 200-RM with 30Mbps Upstream License and Companion Processor. Supports S2 or S2x Modes (Recommend iGW Hub Side for Scale/Throughput - Required for S2x Deployments)
	BP-IQ200/CBH-100-AC: Cellular Backhaul Remote Bundle. Support for 2G/3G/4G with IPSEC. Up to 100 Mbps Maximum CBH throughput with 10K Sessions. Includes iQ-200-RM with 30Mbps Upstream License and Companion Processor. Supports S2 or S2x Modes (Recommend iGW Hub Side for Scale/Throughput - Required for S2x Deployments)
	BP-IQ200/CBH-200-AC: Cellular Backhaul Remote Bundle. Support for 2G/3G/4G with IPSEC. Up to 200 Mbps Maximum CBH throughput with 10K Sessions. Includes iQ 200-RM with 15Mbps Upstream License and Companion Processor. Supports S2 or S2x Modes (Recommend iGW Hub Side for Scale/Throughput - Required for S2x Deployments)
	BP-IQ200/CBH-50-DC: Cellular Backhaul Remote Bundle. Support for 2G/3G/4G with IPSEC. Up to 50 Mbps Maximum CBH throughput with 10K Sessions. Includes iQ 200-RM with 30Mbps Upstream License and Companion Processor. Supports S2 or S2x Modes (Recommend iGW Hub Side for Scale/Throughput - Required for S2x Deployments)
	BP-IQ200/CBH-100-DC: Cellular Backhaul Remote Bundle. Support for 2G/3G/4G with IPSEC. Up to 100 Mbps Maximum CBH throughput with 10K Sessions. Includes iQ 200-RM with 30Mbps Upstream License and Companion Processor. Supports S2 or S2x Modes (Recommend iGW Hub Side for Scale/Throughput - Required for S2x Deployments)
	BP-IQ200/CBH-200-DC: Cellular Backhaul Remote Bundle. Support for 2G/3G/4G with IPSEC. Up to 200 Mbps Maximum CBH throughput with 10K Sessions. Includes iQ 200-RM with 15Mbps Upstream License and Companion Processor. Supports S2 or S2x Modes (Recommend iGW Hub Side for Scale/Throughput - Required for S2x Deployments)

Hub-Side Solution	**BP-Sathaul-XE-CG/R630:** Central Gateway Cellular Backhaul Applications Bundle. Support for 2G/3G/4G with IPSEC. 400 Mbps Maximum throughput. Includes Dell R630 Universal Compute Server.
	BP-Sathaul-XE-iGW/FC640: Intelligent Gateway Cellular Backhaul Applications Bundle. Support for 2G/3G/4G with IPSEC. 1.0 Gbps Maximum throughput. Includes Dell FC640 Universal Compute Sled. (Requires available iGW Processing Slot)
	LIC-SatHaul-XE-VM: License, SatHaul-XE-VM CBH license Private Cloud De-ployments up to 1.3 Gbps. Support for 2G/3G/4G with IPSEC. Primary or Redundan-cy License (Requires customer Private-Cloud infrastructure and Professional Services Custom SoW & Install)
Starter Kit Bundles	**BP-Sathaul-XE-SB-1:** SatHaul-XE Starter Bundle - 1 Central Gateway Cellular Backhaul Applications Server. Support for 2G/3G/4G with IPSEC. 200 Mbps Maximum throughput. Includes Dell R630 Universal Compute Server. Qty 10 X7-EC Remotes for CBH Applications. (Requires Professional Services Installation from Services Line Item Below)
	BP-Sathaul-XE-SB-2: SatHaul-XE iGW Starter Bundle - 1 iGW Backhaul Applications Server. Support for 2G/3G/4G with IPSEC. 200 Mbps Maximum throughput. Includes Dell FC640 Universal Compute Sled. Qty 10 X7-EC Remotes for CBH Applications. Remotes for CBH Applications. (Requires Professional Services Installation from Services Line Item Below)
Installation Services (Required)	**SERV-Sathaul-XE-Base:** Sathaul-XE Professional Base Installation Service. 3-Day On-Site Installation and Hands-on training. Includes T&E.
	SERV-Sathaul-XE-Custom: Sathaul-XE Professional Custom Installation Service. 5-Day On-Site Installation and Hands-on training. Includes T&E. Contact Professional Services for SoW

Additional Information

For more information regarding Cellular Backhaul, please contact your account team.