LinkIP ROUTED MULTI-DESTINATION™ OVERLAY

How to net huge bandwidth savings on existing SCPC networks

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1. INTRODUCTION

This application note outlines a solution for network upgrades that provides significant bandwidth savings in existing SCPC networks. The upgrade consists of adding LinkSat's LinkIP router to existing network equipment and converting the network to LinkSat's unique dynamically routed network architecture.

The LinkIP is a multi-port services platform that can be configured to exactly match the network requirements. It is an advanced WAN to LAN router that utilizes three powerful tools for realizing bandwidth savings on three separate layers:

- Routed Multi-Destination^{TM} (RMD) network architecture
- LinkShrink^{TM}, a proprietary data compression engine that is capable of impressive compression rates
- LinkCast^{TM}, LinkSat's proprietary layer 1.5 transport protocol that enables dynamic routing within a RMD network

Each tool saves bandwidth on a different layer. When used together and overlaid into existing network hardware, these tools can cumulatively result in substantial bandwidth savings.

2. NETWORK ARCHITECTURE

RMD is a network architecture that uses IP multiplexing to aggregate outbound traffic at the hub, so that the hub can transmit a single outbound carrier that is received by all sites in its network or sub-network. By aggregating all IP transmit streams into one carrier, statistical multiplexing gains achieved by averaging out peak and valley traffic of multiple IP streams realizes bandwidth savings. Elimination of carrier spacing, required when transmitting discrete SCPC carriers, puts otherwise wasted space to work, increasing bandwidth potential in frequency allotments.

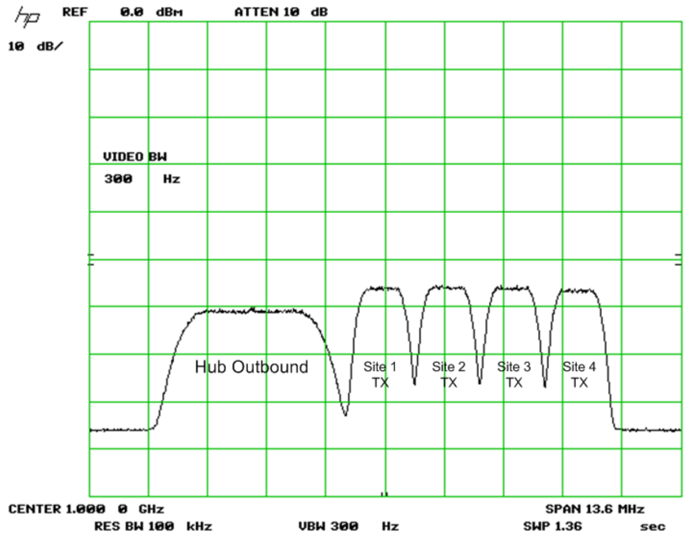
RMD has proven to be a highly efficient and flexible IP transport methodology for star, partial mesh, and full mesh network architectures. In a star network environment, RMD consists of a single aggregate outbound carrier from the hub, and multiple SCPC inbound carriers from the remote sites. IP packets are dynamically routed in the RMD network typically using well known protocols such as OSPF and BGP. Use of these routing protocols in conjunction with LinkCast, a unique dynamic routing address scheme, allows efficient transport and highly effective packet filtering at each site. Packet prioritization can easily be configured using the native differentiated services and QoS capabilities of the router.

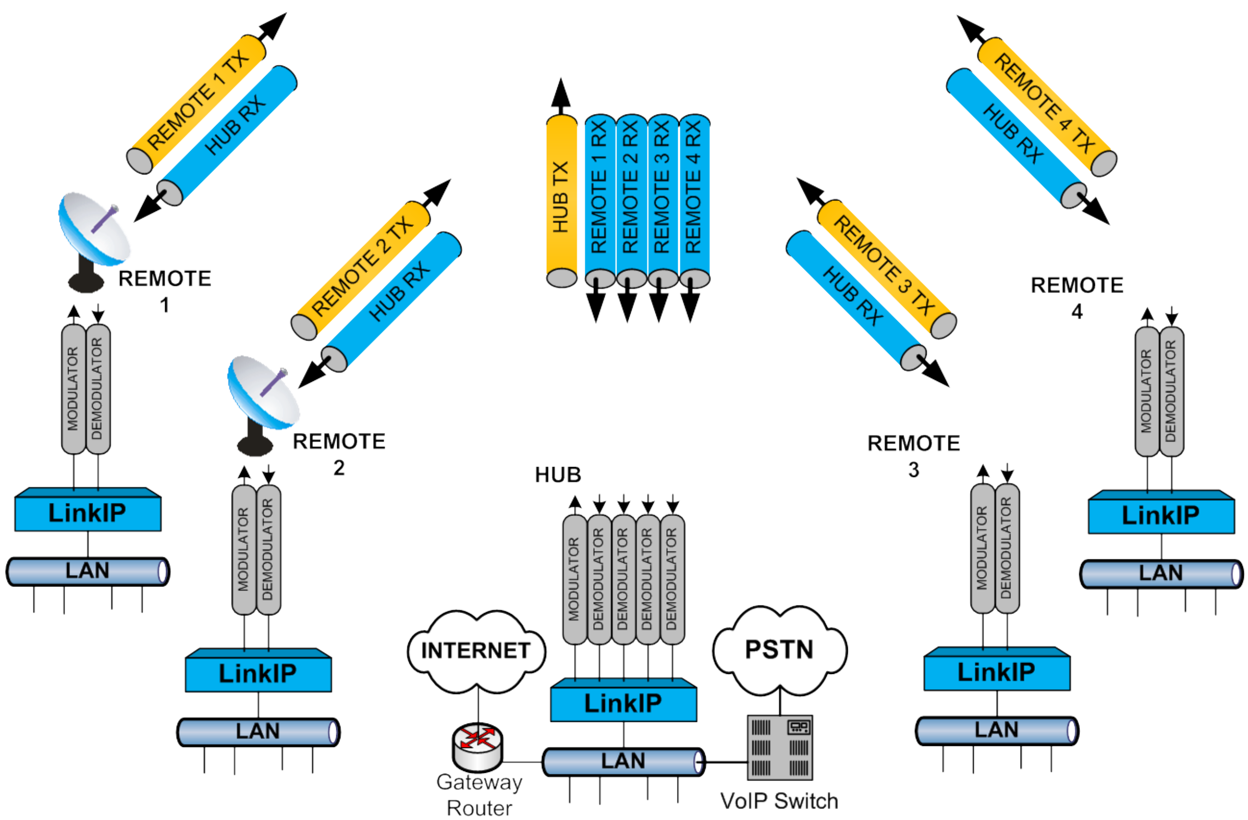
The outbound carrier from the hub can use any transport format (QPSK, 8PSK, TPC, DVB, etc). The upgrade example in this paper, however, uses a DVB-S2 outbound carrier. The advantages of DVB-S2 are 1) it allows use of low cost, integrated DVB-S2 IRDs at the receive sites; 2) it allows use of highly efficient advanced modulation (8PSK or 16QAM, depending on what links budgets will support), and 3) it provides near theoretical BER for Eb/No performance, which is important for remote sites using small antennas. A further advantage of this approach is that new circuits can easily be added to the multicast carrier. The only new hub equipment required for addition of new remote sites is a demodulator for each new inbound carrier.

Due to the statistical multiplexing done on the individual IP streams into a single stream, further bandwidth savings can be realized by oversubscribing the outbound circuits. In a typical SCPC network, each carrier is sized to accommodate the peak traffic for that route. Bandwidth gains are realized by aggregating traffic and averaging out the individual fluctuations in traffic demand for each site. During traffic spikes, lower priority packets can be queued up by the LinkIP so that the circuit does not have to be sized for the absolute peak traffic periods. This "oversubscription" allows a reduction in size of the outbound carrier without noticeably impacting overall network performance.

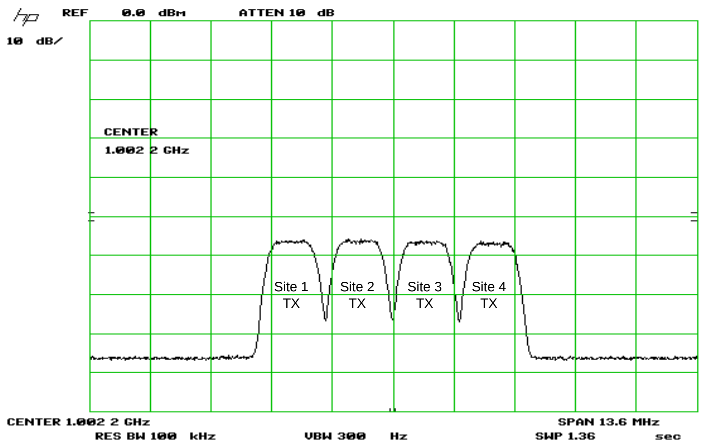
Each remote site receives the aggregate outbound traffic, and the LinkIP router at each site filters packets, dynamically routing those packets destined for its local network, and discarding the rest. LinkCast is a unique addressing and routing scheme that efficiently filters and forwards without duplicate packets into the network and without the high overhead of Ethernet.

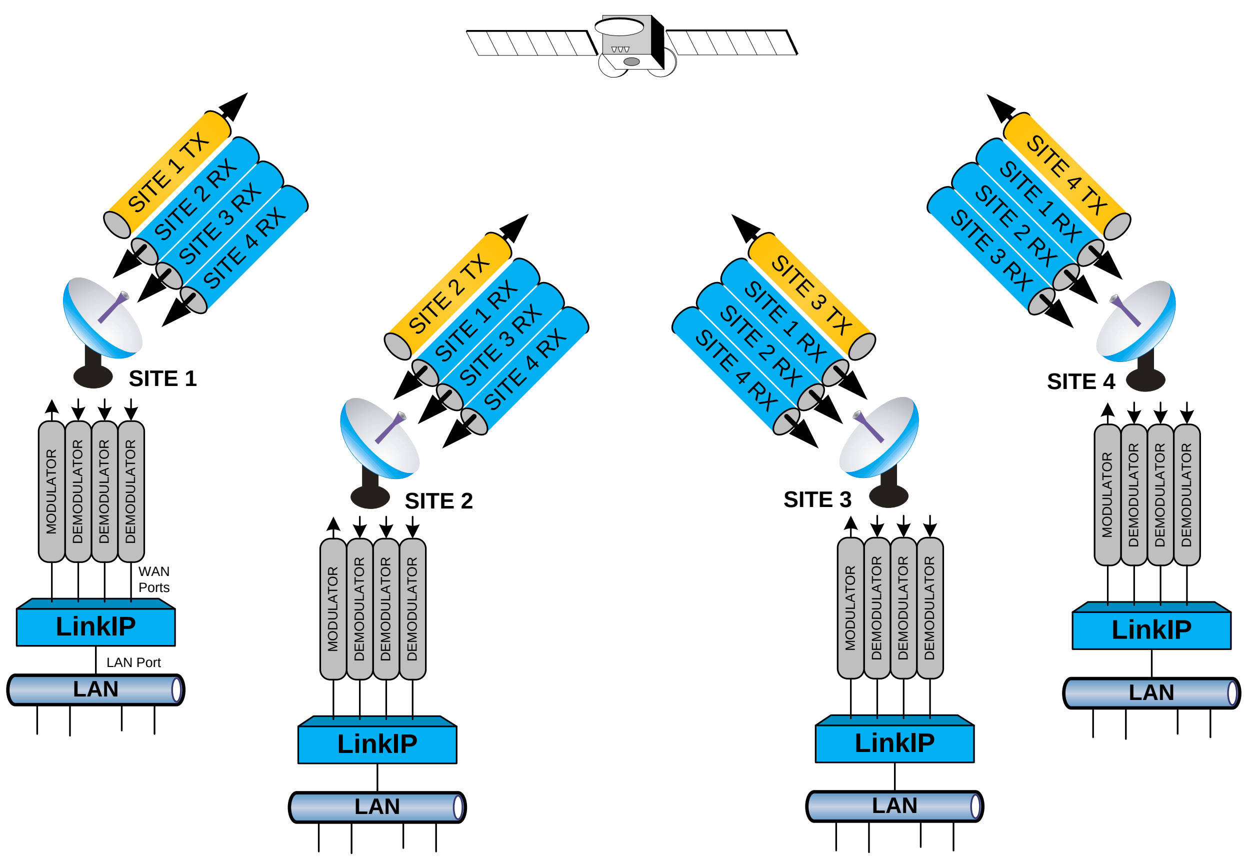
The inbound channels from the remote sites are discrete SCPC carriers. These inbound channels can use existing modem equipment. Addition of single hop remote to remote links for partial mesh capabilities within the RMD architecture is just a matter of adding another demodulator to each remote that wants to have a single hop connection to another remote. The additional demodulator would be tuned to the outbound carrier of the remote site to which it wants to connect. If remote 1 wants to establish a single hop link to remote 2, for example, both sites would add a demodulator. Remote 1 would tune the new demodulator to remote 2's transmit frequency, and remote 2 would tune its new demodulator to remote 1's transmit frequency. In order to convert to partial or full mesh in the network example used in this paper, all modulators in the network would need to be the same, e.g. DVB-S2, 8PSK TPC, etc.





Routed Multi Destination Network Architecture – STAR





Routed Multi Destination Network Architecture – Mesh

3. LinkShrink™ DATA COMPRESSION

LinkShrink is LinkSat's proprietary lossless data compression system that was designed specifically for LinkSat's RMD solution. Its high-performance data compression algorithms can achieve 60% or more bandwidth savings on compressible data. Head to head tests with other satellite equipment manufacturers' compression systems using same data files consistently show LinkShrink achieving much higher levels of compression.

The LinkIP hosts the LinkShrink compression system. The lossless, low latency engine compresses both packet header and payload. LinkShrink makes compression decisions on a packet by packet basis. Each packet is handled by the compression system based on characteristics, TOS, IP protocol, UDP port, TCP port and combinations of these as well. Packet headers are compressed first. The resulting datagram may be sent through a stream compression engine depending on its characteristic. If the requirement is for maximum compression it is sent through the standard stream compressor. If the packet is sensitive to latency, such as a voice signaling packet, it is sent through the zero latency stream compression. The resulting packet is then encapsulated in the LinkCast protocol and routed out to the satellite modulator.

Compression can be set up or bypassed on a per WAN port basis, and can be set up or bypassed on an IP stream, destination IP address, or packet type basis as well. Packet prioritization is achieved by using the router's QoS capabilities, or can be set by IP protocol, UDP port, TCP port, combinations of UDP port and TOS. Although already extremely low, throughput latency and packet jitter can also be controlled by adjusting the level of compression.

As with any compression system, compression levels achieved by LinkShrink depend on data type. Compression ratios of 2:1 or better can be achieved with highly compressible data, for example VoIP, TCP and UDP file transfers, and uncompressed voice. Ratios of 1.5:1 or better can typically be achieved with compressed voice in VoIP networks, e.g. from media gateway equipment and on A-bis and A-ter links.

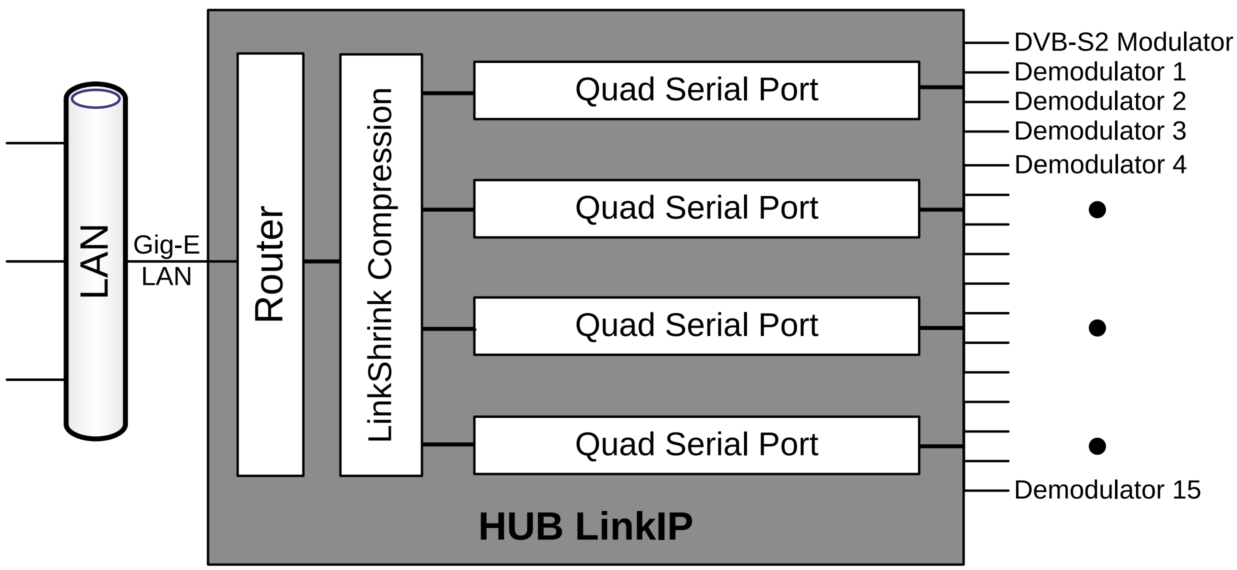
4. NETWORK UPGRADE EQUIPMENT EXAMPLE

The primary objectives of the LinkIP solution are to offer maximum bandwidth savings while minimizing capital expenditures. The example presented here is a hypothetical, existing SCPC network into which a LinkIP solution will be overlaid. It assumes a 70 site network in a star configuration. The solution for this example is engineered to balance bandwidth savings benefit with minimizing capital outlay by maximizing use of as much of the existing equipment as possible.

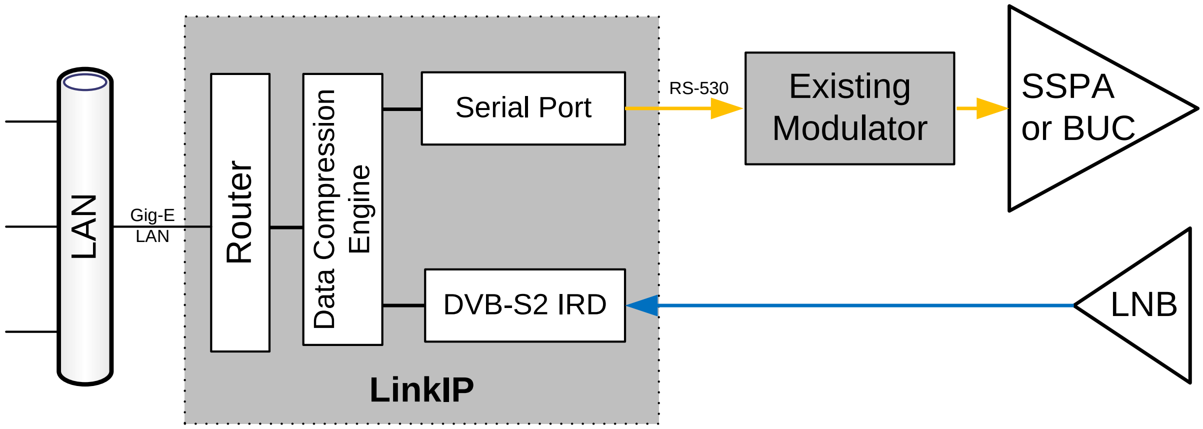
The hub equipment typically consists of a hub LinkIP, along with expansion chassis equipped with multiple serial ports for interfacing with existing modems. On the receive chain, each serial port passes received traffic from its demodulator to the LinkIP. The transmit chain consists of a DVB-S2 modulator for transmission of aggregate network outbound traffic. The DVB-S2 modulator interfaces with a serial port on the LinkIP.

The remote equipment consists of a LinkIP equipped with an Ethernet port for connection to the local network, serial port for connection to the existing modulator for the remote outbound channel, and an internal DVB-S2 Integrated Receiver Decoder (IRD) for reception of the hub outbound carrier. The DVB-S2 IRD requires a PLL LNB at each remote site.

Each LinkIP is also equipped with LinkShrink™, which is LinkSat's proprietary data compression engine. LinkShrink is an in-line compression system that resides in the LinkIP and compresses both IP headers and payload data. Compression gains depend on the type of payload data being compressed. The LinkIP serial ports in this example can be configured to accommodate RS-530, RS-422, and V.35 modem interfaces. Other serial port types are also available (E-1, ASI, etc).



HUB Block Diagram



Remote Block Diagram

5. BANDWIDTH SAVING ESTIMATES

The calculations below are based on a hypothetical network. The first table shows bandwidth used by the existing SCPC network. The second and third tables show outbound and inbound carriers for the LinkIP solution. All hub transmit data streams for the network are multiplexed into a single IP stream and compressed by the LinkIP, and then fed to the DVB-S2 modulator. The aggregate carrier is then multicast to all remote sites. Transmit outbound FEC used in these calculations is 5/6 @8PSK, higher FECs and / or modulation types can possibly be used for more bandwidth efficiency depending on what link budgets will support.

Estimated bandwidth savings are 10% on the outbound carrier for statistical multiplexing gains, and assuming a worst case overall 30% savings from compression. Tests using actual network traffic can determine actual performance.

EXISTING SCPC

Circuit (kbps)	qty links	FEC rate	FEC type	MI	SR (MHz)	Carrier Space	Total BW (kHz)
1024	20	3/4	TPC	2	682.667	1.3	17,749.333
512	20	3/4	TPC	2	341.333	1.3	8,874.667
448	10	3/4	Viterbi	2	298.667	1.3	3,882.667
256	10	3/4	Viterbi	2	170.667	1.3	2,218.667
128	10	3/4	Viterbi	2	85.333	1.3	1,109.333
TOTAL OCCUPIED BANDWIDTH, SCPC							**33,834.667**

Multi-Destination OUTBOUND, DVB-S2 64K BLOCKS

Circuit (kbps)	qty links	FEC rate	FEC type	MI	SR (MHz)	Carrier Space	Total BW (kHz)
1024	10	5/6	LDPC/BCH	2.5	495.484	1.0	4,954.839
512	10	5/6	LDPC/BCH	2.5	247.742	1.0	2,477.419
448	5	5/6	LDPC/BCH	2.5	216.774	1.0	1,083.871
256	5	5/6	LDPC/BCH	2.5	123.871	1.0	619.355
128	5	5/6	LDPC/BCH	2.5	61.935	1.0	309.677
TOTAL OCCUPIED BANDWIDTH, DVB-S2 OUTBOUND						1.3	**11,806.452**

Multi-Destination INBOUND CARRIERS

Circuit (kbps)	qty links	FEC rate	FEC type	MI	SR (MHz)	Carrier Space	Total BW (kHz)
1024	10	3/4	TPC	2	682.667	1.3	8,874.667
512	10	3/4	TPC	2	341.333	1.3	4,437.333
448	5	7/8	Viterbi	2	256.000	1.3	1,664.000
256	5	7/8	Viterbi	2	146.286	1.3	950.857
128	5	7/8	Viterbi	2	73.143	1.3	475.429
TOTAL OCCUPIED BANDWIDTH, INBOUND CHANNELS							**16,402.286**

TOTAL OCCUPIED BW, SCPC	33,834.667
TOTAL OCCUPIED BW, ROUTED MULTI-DESTINATION	28,208.737
TOTAL OCCUPIED BW, RMD, w/ STAT MUX GAINS (estimated @ 10% on OB carrier)	27,028.092
TOTAL OCCUPIED BW, RMD, w/ STAT MUX GAIN and COMPRESSION (estimated)	18,919.665
TOTAL ESTIMATED LINKIP BW SAVINGS VS SCPC	**14,915.002**
NET BANDWIDTH SAVINGS, PERCENT	**44.08%**