Key Features of the Hughes HN System

HN System Overview

The HN System provides **high-speed Internet Protocol (IP) satellite connectivity** for multiple remote sites connecting to a corporate headquarters or the Internet. This is an innovative broadband system designed and optimized for networks that require **high bandwidth and flexible policies for quality of service (QoS)**. As shown in Figure 1, the network architecture is based on a TDM/TDMA star topology and operates in the Ku, Ka, and C frequency bands.

- The HN System leverages the **DVB-S2 ACM transmission standard** for the outbound channel to achieve the **best spectral efficiency of any TDM/TDMA network on the market**.
- The HN System **optimizes link performance**, even in networks with geographically diverse locations and in high rain areas, by dynamically adjusting error-correcting codes and modulation based on signal quality feedback from HN remote terminals, giving Hughes customers **higher system availability and greater throughput for a given antenna size**.
- The TDMA **inbound channel uses variable burst lengths**, providing up to 85% efficiency on the return channel.
- A state-of-the-art Adaptive Inroute Selection (AIS) capability for the inbound channel **enables dynamic and real-time switching** of the coding rates and uplink power control. Coupled with the DVB-S2 ACM outbound capability this **provides unparalleled network availability**.
- The HN System is **compliant with IPoS** (IP over Satellite), the first global satellite industry standard approved by TIA in North America, and ETSI and ITU in Europe.

Advanced bandwidth management features and traffic prioritization enables operators to **tailor QoS to meet the needs of a diverse network** with multiple applications and traffic characteristics in a highly efficient and optimized manner. Assignment of inbound TDMA channels is done dynamically based on actual need and usage—thus enabling operators to maximize the benefit of TDMA shared bandwidth while providing the perception of a dedicated service.

The HN terminal is a full-featured IP router which typically eliminates the need for a separate router at the remote site.

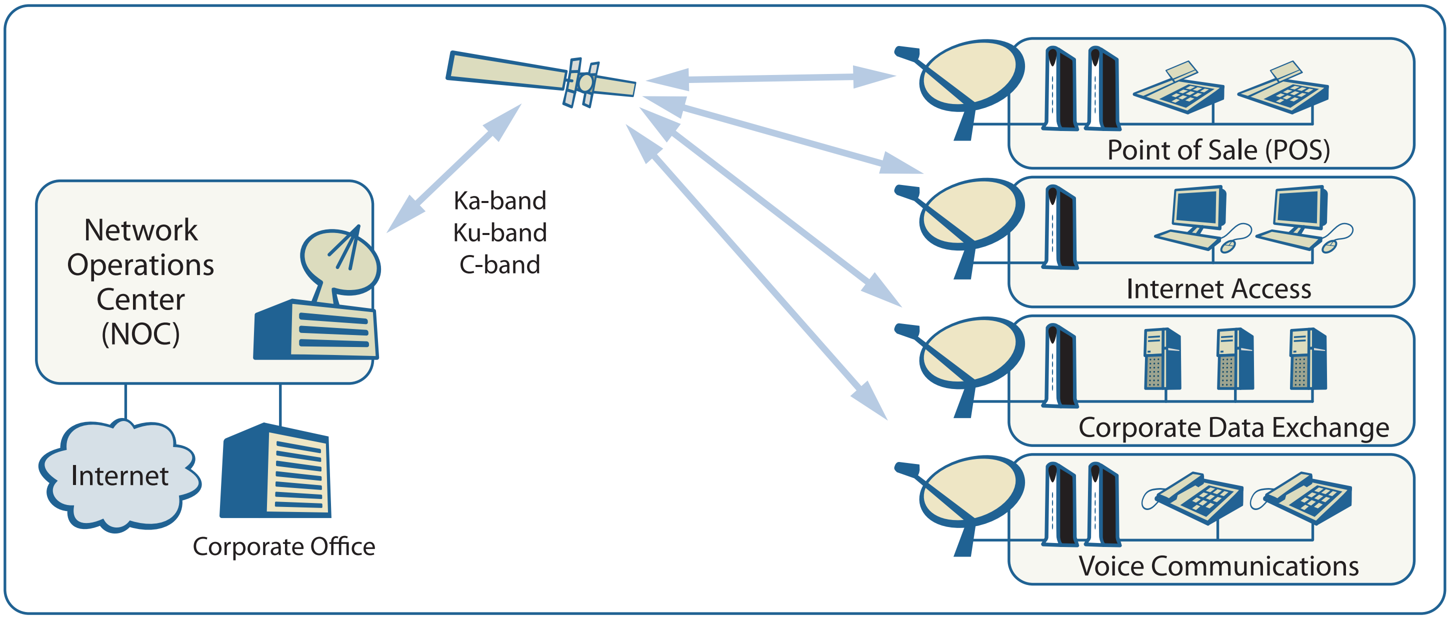

Figure 1. Network Architecture

Transport Characteristics

All the Hughes satellite IP broadband systems use the DVB standard for the outbound transmission channel. This provides several significant advantages for an operator:

DVB Scales Effectively

Digital Video Broadcast (DVB) channels are designed to scale effectively to large carriers. Hughes can support carriers as low as 1 Msps or as large as 45 Msps on the outbound channel. This contrasts sharply with systems where the maximum outbound channel capacity can be no more than 10 Msps. Thus, an operator is not forced to uplink multiple outbound channels artificially. Using multiple channels results in an efficiency penalty as each additional carrier requires channel spacing. In addition, the advantage of satellite multicast is reduced as each outbound carrier must replicate every multicast message.

DVB-S2 Spectral Efficiency

The most recent enhancement to the DVB series of standards is DVB-S2, which introduces several important features that together provide significant spectral efficiencies when compared with DVB-S and proprietary (non-DVB) channel formats. DVB-S2 provides for both 8 PSK as well as QPSK modulation and uses a powerful FEC system based on concatenation of BCH with LDPC (Low Density Parity Checking) inner coding. The LDPC technology was developed by Hughes and adopted by the DVB standards committee as the basis for the new DVB-S2 standard. The result of the BCH/LDPC coding is only 0.7 db from the Shannon limit. This is significantly better performance then any proprietary *turbocode*—the best of these appear to operate about 2 dB from the Shannon limit. Figure 2 shows the performance of DVB-S2 against DVB-S, as well as a typical proprietary *turbocode* signal.

The bottom line for operators is that the DVB-S2 standard can provide 2.25 bits per Hz or more, an increase of 30-40% over conventional DVB-S carriers, resulting in better bandwidth economics.

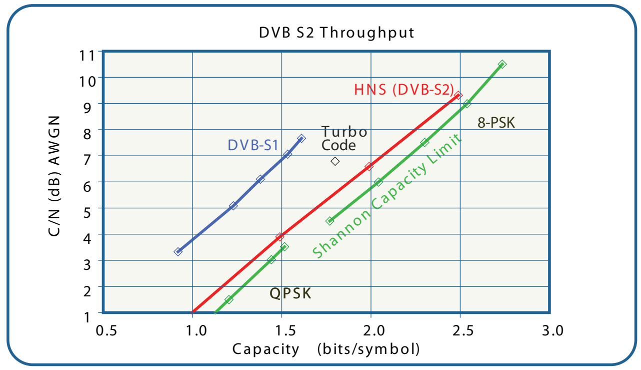

Figure 2. DVB-S2 Performance

DVB-S2 Outbound Adaptive Coding and Modulation

A very powerful feature of DVB-S2 is the Adaptive Coding and Modulation (ACM) capability, which was especially designed for diverse broadband IP over satellite systems. Hughes was the first manufacturer to deliver a functioning ACM system and has delivered over 450,000 VSATs for operation in DVB-S2 ACM networks as of the first quarter of 2008.

ACM allows the system to vary dynamically the modulation and coding of the outbound channel for each transmission. This feature can be applied in two ways—first to optimize the link budget of the outbound channel and second to make dynamic adjustments to compensate for atmospheric attenuation of the outbound channel.

Optimizing the link budget —An operator can predefine the outbound coding/modulation combinations for each remote based on the satellite *footprint* or EiRP contour. As shown in Figure 3 the remote terminals that are at beam edge can be configured for the most robust coding/modulation combination (QPSK Rate ½), while the remote terminals at beam center can be configured for the most bandwidth efficient coding/modulation combination (8 PSK Rate 9/10). The ability to customize the outbound channel per remote enables an operator to realize additional bandwidth efficiencies of up to 30% over and above the 30% gain from the DVB-S2 coding. Thus, DVB-S2 with ACM can provide an operator up to 60% bandwidth gain over DVB-S.

Outroute availability—In the second application of the ACM feature, the system is able to change dynamically the coding/modulation combination based on changing received signal conditions as occurs in the event of a rain fade. In this mode there is a *closed loop control* feedback mechanism between the NOC and the remote, whereby the remote can instruct the NOC to change the coding/ modulation combination to overcome rain fade. The benefit for an operator is the ability to provide higher availability to its customers.

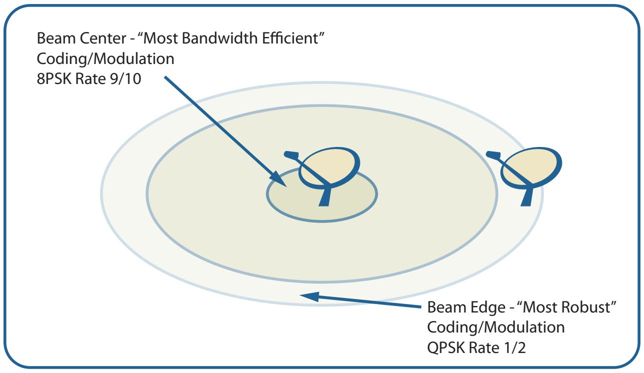

Figure 3. Using ACM to Optimize the Link

Inroute Efficiency

The HN broadband system is a true dynamic bandwidth assignment system. If a remote site has no traffic, no system resources are assigned to that site. Once a site receives a traffic assignment (requested via an Aloha supervisory channel), the remote goes into a *stream* mode (non-contention), and the amount of bandwidth assigned is based on the QoS plan and current need of the individual remote.

By contrast some systems have no mechanism for sharing a supervisory channel. In these systems, every remote in the system must be pre-assigned with network capacity, always and forever. This is extremely inefficient, particularly for large networks.

In addition, variable burst length transmissions are used for the inbound allowing the return channel burst size to be built optimally per remote and per demand. This is in contrast with systems that use fixed burst length sizes, where every inbound burst must be the same size regardless of actual payload demands, thereby leading to significant wastage of bandwidth.

Extensive tests on the throughput of the HN inbound system demonstrate inbound efficiency up to 85%. In practical application, this means that the upstream performance typical of Hughes terminals easily reaches 85% of the inbound channel rate—1.3 Mbps upstream throughput in the case of a 1.6 Mbps return channel.

Inroute Bandwidth Pooling

Taking advantage of the fact that all remote terminals are fully frequency agile across all inbound channels (as illustrated in Figure 4), the system is able to *bundle* the inbound channels into a single large pool of resource. At any point in time a remote terminal may be instructed to access any inbound channel.

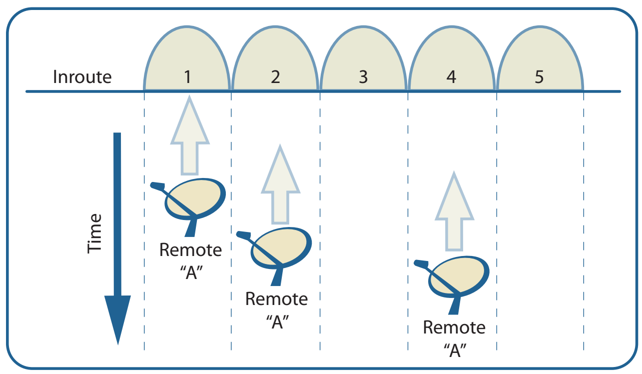

Figure 4. Multifrequency Inbound Access

In order to achieve the efficiencies of pooling (that is, realize the effects of the *law of large numbers*) and at the same time provide the quality of service committed for each remote terminal, the system utilizes a number of techniques. An important element is the concept of Inroute Quality of Service (IQoS) plans. Each IQoS plan is simply the logical partition of inroute bandwidth together with the set of remote terminals that can access the logical bandwidth assigned to the IQoS plan. The IQoS plan defines the maximum amount of bandwidth available to a group of remote terminals when there is network bandwidth contention. Multiple IQoS plans may be defined enabling an operator to provide differentiating levels of service. Remaining inroute bandwidth and unused IQoS bandwidth is designated *Open* and is available for allocation as *Best Effort* to remote terminals that are not assigned a fixed IQoS plan. The structuring of the inroute bandwidth is illustrated in Figure 5.

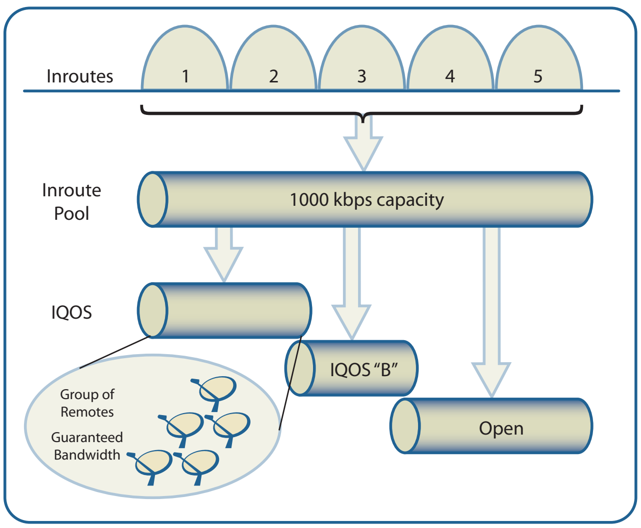

Figure 5. Inbound Pooling

An important element in the inbound allocation scheme is that bandwidth is never *dedicated* (hard assigned to a remote terminal or group of remote terminals) but is always *guaranteed*. The advantage is that when an IQoS plan does not fully utilize its assigned bandwidth, the system is free to reallocate this bandwidth to other IQoS plans, thus providing significant flexibilities to an operator.

Network Availability

Recognizing that high availability is a crucial element of service, the HN System provides the industry's most extensive set of features for increasing system availability.

Closed Loop Control—The HN System has a *closed loop control* between the hub and the remote terminals for continuous monitoring of the outbound and inbound channels. The closed loop control allows the hub to continuously monitor the received signal quality of transmissions from each remote and provide this information in a constant feedback to the remote. In addition, each remote continuously monitors the received signal quality of the transmission from the hub. As atmospheric conditions affect the link quality, each component is able to initiate changes to overcome fade conditions.

Uplink Power Control—If the remote detects a fade condition, it is able to change dynamically its local uplink power control to attempt to overcome the fade conditions.

Adaptive Coding—The HN System also is able to change dynamically the FEC coding rate of the inbound channel. This feature brings significant benefits in the form of higher link availability. As shown in Figure 6, the return channel demodulators at the hub station are able to demodulate, decode, and process bursts of varying coding rates within the same TDMA frame. The hub demodulator does not need to know in advance the coding of each burst; this is determined *on the fly*, allowing the remote to dynamically change its coding rate based on link conditions as affected by rain fade.

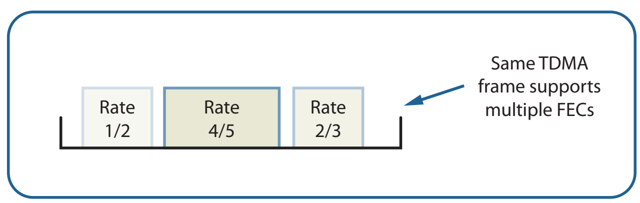

Figure 6. Multiple FECs Within One TDMA Frame

Inroute Agility—Should the remote terminal need even more robust link performance for the inbound transmissions, it also has the ability to *gear shift* to a different inroute group supporting a lower symbol rate.

These availability features, together with the DVB-S2 ACM capability, result in unparalleled link performance that is critical for any business application.

Advanced Bandwidth Management Capabilities

In addition to the logical partitioning of inbound bandwidth, the HN System enables an operator to tailor bandwidth assignment to meet application requirements for jitter and latency or to prioritize one application over another.

Best Effort Services—The HN System allocates bandwidth fairly and proportionally to all remote terminals requesting bandwidth, based on demand. Under this scheme, outbound and inbound bandwidth for a remote terminal is provided as needed but subject to the constraints of the overall network load and IQoS capacity.

Constant Bit Rate (CBR) Services—The HN System can be prioritized to provision fixed amounts of inbound bandwidth independent of advertised demand from a remote terminal. Integrated client applications (such as VoIP) use the CBR protocol to request pre-allocation of inbound bandwidth on initiation of a session to provide high-quality voice and fax communications. Remote terminals may be configured to allow concurrent use of CBR and Best Effort bandwidth when supporting mixed traffic.

On-Demand Streaming (ODS)—ODS enhances the availability of CBR services to allow real-time applications such as third-party Voice over Internet Protocol (VoIP) devices and videoconferencing devices to work seamlessly over the HN System. These applications require constant bit rate bandwidth on the inroute on a demand assigned basis. The remote terminal identifies latency-sensitive data streams, automatically requests CBR bandwidth for active streams, and releases bandwidth as the streams stop. The remote terminal identifies target applications based on IP Selection Rules (e.g. by IP addresses, port ranges, DSCP values, and other header fields) or through a SIP sniffer. Additional support for SIP includes call set-up snooping and codec-specific bandwidth reservation.

Traffic Prioritization—With any network it is vital to apply prioritization to ensure that business-critical applications do not suffer due to bandwidth contention with non-vital applications. The HN System can be configured to prioritize inbound and outbound traffic based on IP traffic characteristics (e.g. by IP addresses, port ranges, DSCP values, and other header fields). This allows prioritization based on a machine or application level. Prioritization is managed at two levels. Within the site, prioritization governs the use of bandwidth assigned to the site. At a higher level, the network assesses prioritization across all sites and ensures higher priority traffic has first access to bandwidth when handling over-subscription of overall network bandwidth. As an example, this capability prevents a critical application at site X from experiencing diminished performance because site Y is transmitting a large background data file. A weighted fair access mechanism is employed to ensure no traffic is starved when network demand exceeds the total network bandwidth.

Network Security

The HN System includes a Conditional Access mechanism which is used to prevent remote terminals from eavesdropping on the outbound traffic being sent to other remotes. In addition, the HN System provides a standards-based IPSec/IKE implementation for AES encryption of user data traffic and managing encryption keys in a Hughes network. The IKE (Internet Key Exchange) protocol is used to automatically generate and maintain 128-bit session keys and to set up a secure IPSEC tunnel between the HN terminal and the NOC or extended to the customer's data center. Encryption is implemented for both inbound and outbound traffic. The HN security kernel has received NIST certification for FIPS 140-2 level 1 operation.

Because the encryption function is integrated within the HN System, the acceleration and traffic prioritization functions typically available in an HN network are maintained.

Full-featured IP Router

The Hughes family of VSAT satellite routers provides a full-featured IP router functionality, generally eliminating the need for an external router at remote sites.

IP Protocols—The HN routers support all common unicast and multicast IP protocols, including TCP and UDP, and the protocols carried on top of them (HTTP, SSL, RTP, SIP, etc.). The routers also support other IP protocols such as ICMP, IGMPv3, etc.

Routing Protocols—The HN routers support a wide range of routing protocols enabling network interoperability, including:

- RIPv2, ICMP, ARP
- BGP—The HN network edge components operate as BGP edge routers and exchange routes with their BGP peers enabling interoperability with other networks, such as MPLS
- VRRP—Support of the IETF standard Virtual Router Redundancy Protocol (RFC 3768) provides redundant Internet gateways. Increased availability with no single point of failure is achieved by creating a virtual router consisting of a group of cooperating physical routers which share a MAC and IP address, but provide transport diversity
- PBR—The HN network also supports Policy Based Routing which can be used, especially in conjunction with VRRP, to support carrying traffic over all available network paths instead of just the active path
- VLAN Tagging

IP Services—The HN routers provide IP services that are of benefit for both enterprise and consumer applications, such as:

- Flexible addressing with support for network address and port translation (NAPT), NAT with port forwarding, DHCP server, and DHCP relay
- Integrated Access Control List, which controls access from both the local LAN and the external network
- Integrated virus protection

High Performance—All HN routers implement the Hughes Performance Enhancement Proxy (PEP) which includes TCP spoofing, ACK reduction, and message multiplexing. To ensure optimal use of bandwidth, the HN System provides header and data compression on both the inbound and outbound channels. In addition, the HN routers have an integrated optimization targeted for handling and acceleration of Internet traffic. This includes

- DNS caching
- HTTP/HTTPS acceleration through sophisticated prefetch algorithms and caching
- Fenced Internet access to reserve use of satellite bandwidth for approved Internet sites

Integrated Application Services

The Hughes broadband solution includes the capability for integrated application services.

Serial Protocols—The HN7700S router supports both high-speed IP and native serial protocols (such as X.25, SDLC, BSC, and async) in a single, low-cost package. The HN1030, with up to four synchronous / asynchronous connections, can be deployed in conjunction with an HN satellite router if more than one serial connection is required at a site.

Voice over IP—The HN7740S supports high-speed IP and two RJ-11 connectors for integrated voice or fax over IP. On establishment of the VoIP session, the HN7740S requests Constant Bit Rate (CBR) bandwidth over the satellite for the duration of the call. In addition, the codec sampling size is optimized for satellite usage to provide high-quality voice over the satellite. The HN1040, with up to four RJ-11 connectors, can be deployed in conjunction with an HN satellite router if more than two connections are required at the site.

Multicast services—The HN System operates as an IP multicast network to efficiently deliver rich-media or bandwidth intensive files for applications such as digital signage and streaming digital audio and video broadcasts. Due to the fact that bandwidth does not need to be pre-assigned to remote terminals, any of the remote terminals can be configured for *receive only* operation for applications such as IPTV distribution and other digital content distribution applications. The enterprise package delivery capability leverages the efficiencies of satellite multicast to transfer any collection of files to a selected group of sites simultaneously. Delivery options include best effort or return receipt for guaranteed reliable delivery.

Network Operations

Hughes is the largest provider of managed network services in the U.S. operating a network in excess of 400,000 consumer sites and more than 90,000 enterprise sites. This provides a constant feedback cycle between the service operations and engineering, leading to innovative designs to lower the total cost of ownership and increase system performance.

The Hughes Network Management System (NMS) provides centralized configuration and management of all network components, including software upgrades. A network operator is able to upgrade the configuration or software for all remote sites within the network. All network components have an integrated SNMP agent allowing for ease of network management and use of standard off-the-shelf network management tools.

To ensure maximum network availability, the network architecture supports redundancy for all network components. In addition, the architecture supports automated geographic NOC redundancy. With NOC diversity, a remote site will automatically detect a failure in communicating with a NOC and switch to operations on the back-up NOC—providing diversity in *spacelink* and/or NOC services.

Unique to the HN System solution is the integrated capability to support *autocommissioning* for every remote in the network. With this feature no human interaction at the hub station is required at the time of a remote installation and commissioning. Remote configurations are preloaded into the NMS database prior to the remote being installed. Once the remote is physically installed and the antenna aligned, the remote will interact directly with the various hub elements to set power and timing values, download software and parameters, and enter operation. All of this is accomplished without the involvement of an operator at the NOC station.

Not only does this feature allow an operator to scale easily to a large number of installations per day—without the burden of adding staff at the hub station—this feature also significantly reduces the possibility of error so that installs are done right the first time.

Worldwide Presence

Hughes is the recognized market leader for broadband satellite solutions. Beyond our technical advantages, Hughes has a very significant presence worldwide with offices and networks throughout the world with operating companies in the US, Europe, Brazil and India, as well as sales and service offices, and service providers operating networks based on Hughes technology. We have been committed to the business of satellite networking for well over 30 years. Selecting a Hughes solution brings not just the technology advantages but also the support and experience of Hughes.

Visit our Web site, www.hughes.com, for a list of our worldwide office locations and contacts.

Acronym List

Acronym	Definition
ACM	Adaptive Coding and Modulation
AIS	Adaptive Inroute Selection
CBR	Constant Bit Rate
DVB	Digital Video Broadcast
IKE	International Key Exchange
IPoS	Internet Protocol over Satellite
IQoS	Inroute Quality of Service
NOC	Network Operations Center
ODS	On-Demand Streaming
PBR	Peak Bit Rate
PEP	Performance Enhancement Proxy
POS	Point of Sale
QOS	Quality of Service
TDMA	Time Division Multiple Access
VoIP	Voice over Internet Protocol
VSAT	Very Small Aperature Terminal

Proprietary Statement