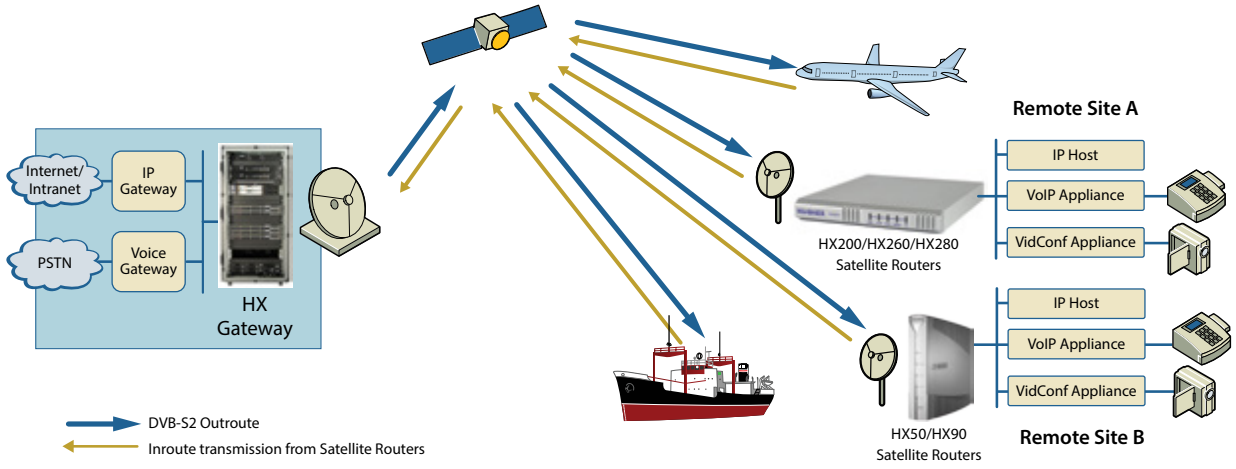
HX System Quality of Service

Designed and optimized for carrier-grade satellite IP broadband networking, the HX System is the ideal choice for service providers seeking to deliver a diverse range of high quality fixed and mobile applications—from digital media, to land/airborne/maritime broadband, to cellular backhaul, mesh, and secure military communications.



Efficiency and flexibility in utilizing satellite bandwidth are core to its design. Fully compliant with the global IPoS/DVB-S2 standard, including Adaptive Coding and Modulation (ACM), the HX System supports any mix of star or mesh networking topologies among a variety of fixed and mobile satellite routers/terminals.

The HX System offers industry-leading configuration tools to optimize both satellite outroute and inroute Quality of Service (QoS), while at the same time providing defined levels of service required for different applications. Each link, whether in star or mesh mode, can be configured to provide a specific QoS for an individual terminal. Additionally, each terminal or group can be independently configured with a unique Committed Information Rate (CIR) or Peak Information Rate (PIR), thereby enabling service providers to readily develop plans tailored to their customers' specific requirements—optimized for the highest QoS at the lowest possible cost.

Advanced Bandwidth Management

Satellite bandwidth is a premium resource that must be shared among users in order to provide cost-effective solutions. Through the powerful and intuitive HX ExpertNMS™ (Network Management System), service providers can access a rich set of features to allocate the right levels of bandwidth and prioritization in configuring QoS levels for a wide range of applications, including:

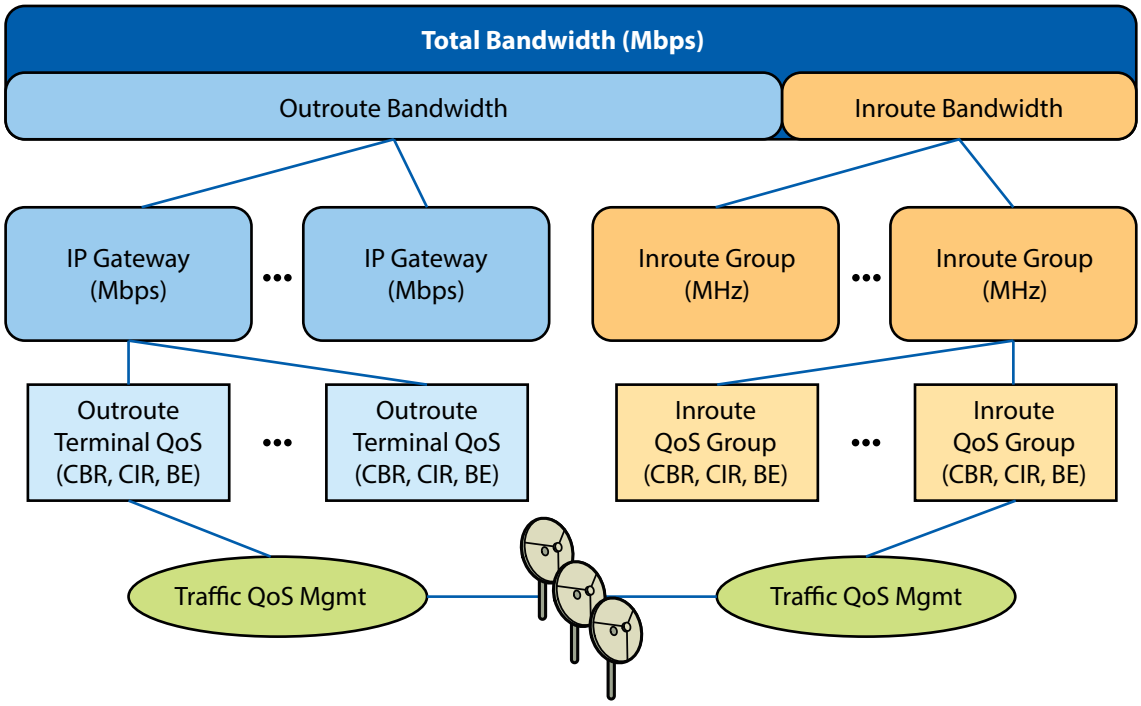
- Voice over IP (VoIP)
- Videoconferencing
- 2G/3G Cellular Backhaul
- Enterprise Resource Planning

- Corporate VPN
- High Availability Networking
- Real-time Command and Control
- SCADA (remote monitoring)

For example, high priority traffic such as VoIP calls can be allocated high priority Constant Bit Rate (CBR) bandwidth with low latency and jitter. Lower priority traffic types, such as FTP and Peer-to-Peer Sharing traffic (which can easily saturate available bandwidth and affect real-time sensitive applications), can be configured so as not to interfere with higher priority applications. During times of congestion, the HX System automatically manages the allocation and prioritization of network traffic to ensure that QoS policies are properly enforced and that high-value applications continue to perform.

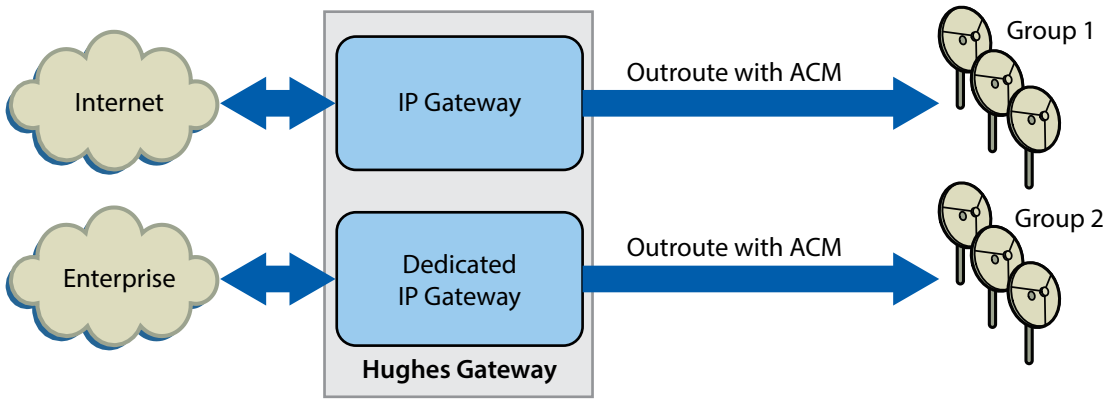
The QoS features of the HX System enable service providers to tailor service delivery to individual satellite routers as well as to groups of satellite routers, thereby customizing service plans to suit the unique needs of each of their corporate clients.

The following figure illustrates the granularity at which bandwidth can be managed.



Outroute QoS

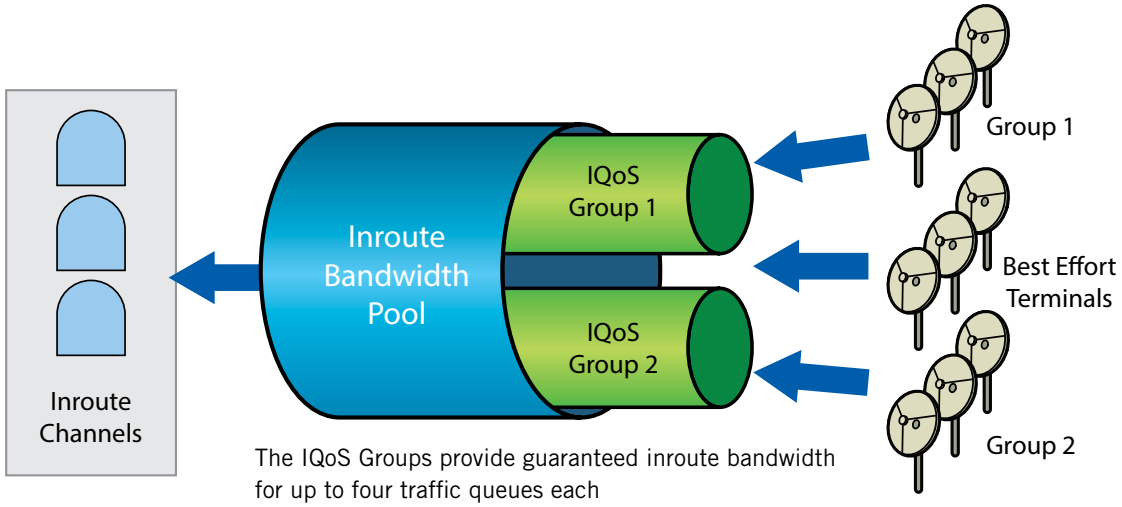
The HX System allows the division of outroute bandwidth to serve defined groups of satellite router which may be assigned to different enterprise customers, VNOs, etc. Each group may have a defined throughput limit; however, oversubscription is a key component of efficient bandwidth utilization and is fully supported. Within each group, traffic is first prioritized according to the QoS classification of the satellite router. For example, a group of satellite routers defined with CIR outroute classification will receive priority over satellite routers defined as "best effort" when the available bandwidth drops; this may be due to simple bandwidth contention, or weather-triggered ModCod changes (the combination of modulation and coding used instantaneously as a result of the DVB-S2/ACM implementation).



An important outbound QoS feature of the HX System is the ability to define a "Real-time Bypass" pipe which eliminates all queuing delays, thereby ensuring the least possible delay and jitter on the outroute. This allows the same DVB-S2 outbound to be shared amongst best effort Internet networks, as well as delay sensitive RAN backhaul networks.

Inroute QoS

Inroute QoS (IQoS) allows the logical grouping of satellite routers so that the system can guarantee availability of capacity in the inroute pool of bandwidth. Multiple IQoS groups may be defined to allow several groups of satellite routers to be assigned a specified amount of inroute capacity, or satellite routers can be left as part of a default "best effort" IQoS group.

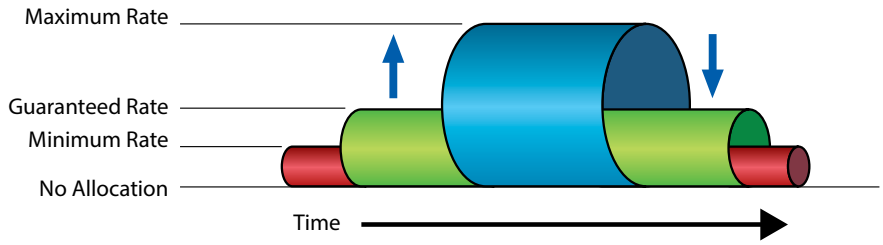


The IQoS Groups provide guaranteed inroute bandwidth for up to four traffic queues each

The HX System allocates virtual capacity, not specific inroute channels, to each IQoS group, thus enabling the system to utilize bandwidth efficiently across the entire pool of inroute channels. This translates into much greater flexibility in bandwidth management, resulting in more users per MHz.

Key features of IQoS include:

- **Guaranteed Bandwidth**—Satellite routers within an IQoS group always have access to at least the configured bandwidth regardless of other traffic activity within other IQoS groups or best effort satellite routers. A percentage of the bandwidth allocated to the IQoS group may be reserved for CBR and CIR.
- **Oversubscription**—Bandwidth may be oversubscribed for CIR services since not every satellite router uses all the bandwidth all the time.
- **Dynamic Allocation**—CIR services may use more than their minimum configured bandwidth up to their maximum if the bandwidth is available as shown in the figure below. Unused bandwidth from an IQoS group can be allocated to other satellite routers outside the group as long as the bandwidth isn't being used by the group.



- **Efficiency**—No bandwidth allocated when VSATs are down or idle.

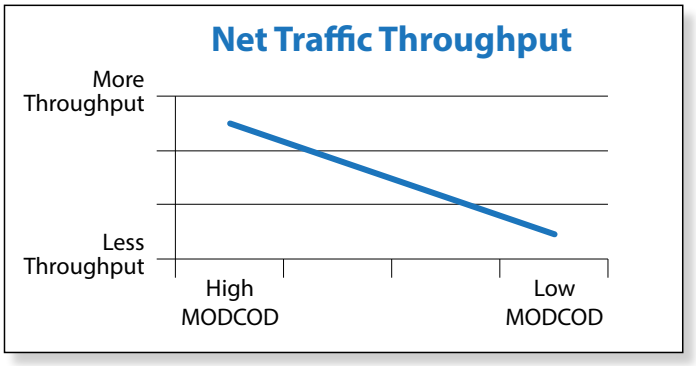
IQoS features allow an operator or VNO to sell megabits rather than megahertz (although both models are supported).

Traffic Congestion Management

Traffic congestion may occur in any transport medium where there is limited shared bandwidth. In satellite systems, the outroute bandwidth, and especially the inroute bandwidth, are valuable resources and must be managed efficiently. Traffic congestion can occur due to:

- Peak hour demands on the network
- Need for critical application bandwidth
- Rain fade

Regarding rain fade, the HX System can dynamically change the modulation and coding in the downlink to the satellite router and in the uplink from the satellite router. Reductions in modulation (e.g., going from 8PSK to QPSK) and reductions in coding (e.g., going from FEC 8/9 to 3/5) mean that as a satellite router within the network experiences fade, the overall net traffic capacity to and/or from that satellite router will drop. This reduction in capacity happens because the system is essentially trading off user capacity, as the figure below shows. A key advantage of the Hughes AIS feature is that rain fade will impact only the satellite routers which are currently in faded condition and not the entire set of users in the network. Hughes AIS allows multiple users running different coding rates to share the same inroute frequency.



The result of traffic congestion is that the HX System must use QoS attributes to allocate bandwidth to higher priority satellite routers and applications because not enough bandwidth may be available to satisfy all CIR requests. QoS is also used in deciding which satellite routers and/or traffic types get bandwidth when the outroute or inroute PIR is oversubscribed.

The HX System applies QoS capabilities at two tiers:

- **Hard QoS:** Satellite routers are classified into QoS profiles that define their prioritization against other satellite routers in the outroute and inroute.
- **Soft QoS:** The system classifies outbound and inbound traffic using IP priorities and other rules.

Satellite Router Classifications (Hard QoS)

QoS starts with assigning traffic profiles to individual satellite routers or groups based on the priority of service plans they will carry, and are defined separately for the outroute and inroute. The following tables summarize the classes of traffic which can be assigned to a satellite router or group, and typical examples of applications.

Outroute QoS Profiles (Highest-to-lowest priority):

QoS Profile	*Definition*	*Examples*
Constant Bit Rate (CBR)	A CBR outroute profile is the highest priority profile simply because the bandwidth is preallocated on the channel; i.e., it is guaranteed bandwidth. Latency and jitter are minimized.	Cellular Backhaul
Committed Information Rate (CIR)	This type of profile allows the satellite router to be defined with a guaranteed minimum bandwidth, as well as defining a maximum rate. The system allows step-wise allocation so that bandwidth is allocated as needed and is not wasted.	VoIP
Best Effort (BE)	No bandwidth is guaranteed to the satellite router on the outroute and is only allocated from available bandwidth.	Internet

Inroute QoS Profiles (Highest-to-lowest priority):

QoS Profile	*Definition*	*Examples*
Constant Bit Rate (CBR)	With this profile, bandwidth is guaranteed with the lowest latency and jitter. Bandwidth may be preallocated or allocated in predefined steps from the minimum guarantee to the maximum.	Leased Line Cellular Backhaul
On-Demand Constant Bit Rate (ODS CBR)	With this profile, the guaranteed bandwidth is allocated as the satellite router requires bandwidth. Bandwidth is allocated to minimize latency and jitter, and is held for a predetermined amount of time and then released if not used. ODS CBR provides SCPC-like capability when needed without the need to sacrifice a whole inroute channel.	VoIP (SIP)
Committed Information Rate (CIR)	This type of profile allows the satellite router to be defined with a guaranteed minimum bandwidth, as well as a defining a maximum rate. If there is no bandwidth requirement from the satellite router, all bandwidth will be deallocated. The system supports step-wise CIR allocation so that bandwidth is allocated as needed and not wasted.	Video
Best Effort (BE)	No bandwidth is guaranteed to the satellite router on the inroute and is only allocated from available bandwidth.	Internet

As described, bandwidth can be guaranteed in different ways, which makes it possible to ensure that satellite routers used in certain critical or time-sensitive applications get bandwidth first. Outroute and inroute classifications and bandwidth allocations need not be symmetrical. It is possible to use virtually all combinations of QoS profiles for a very flexible design.

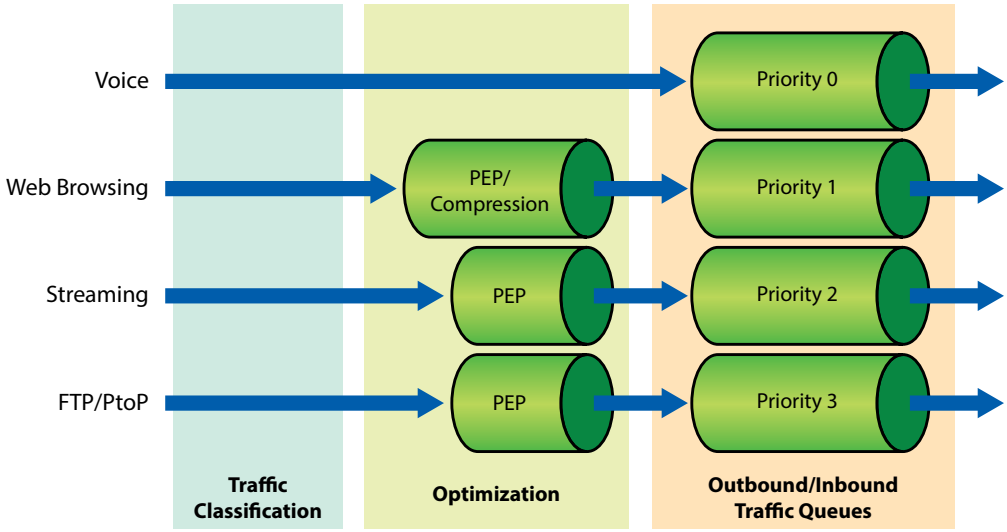
Traffic Prioritization (Soft QoS)

Within a satellite router, it is vital that applications be prioritized by traffic type so that real-time and business-critical applications are not starved of bandwidth during contention or congestion. The Hughes system can prioritize IP traffic based on a combination of the following attributes:

- Source IP address range
- Destination IP address range
- TCP or UDP port numbers
- DiffServ (DSCP) priority bits
- VLAN ID

Further, the system supports Weighted Fair Access, such that during congestion conditions all traffic queues of a given class will receive bandwidth proportionally from the available bandwidth if the CIR rates cannot be met.

There are four priority queues in the system in which traffic can be prioritized. The following illustration is an example of how traffic is prioritized:



During congestion, traffic from the lowest priority queues is throttled first. Note that optimization queues such as Performance Enhancing Proxy (PEP) shown in the illustration may be defined to significantly enhance the user experience for certain traffic types.

Based on the traffic prioritization rules, the system classifies customer traffic, applies optimizations where applicable, and maps the traffic classes to the appropriate traffic queues. At the same time, aggregate bandwidth limits are enforced for IQoS Groups.

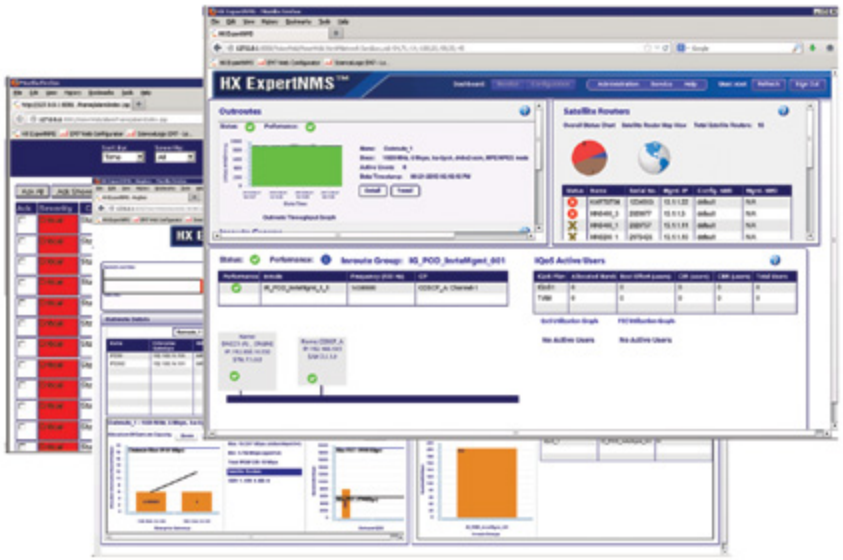
Fair Access Policy

Fair Access Policy (FAP) sometimes has a bad connotation with users. However, it is an important part of the overall QoS a system can provide. The integrated FAP feature can be enabled if necessary and prevents chronic downloaders from using more than their fair share of the capacity over a certain period of time. For example, it is possible to define a FAP profile that limits total capacity utilization over a 24-hour period to 200 megabytes, and then restores the user's capacity over a certain period of time.

Network Monitoring

As noted, all of the features discussed in this paper can easily be configured via the Hughes ExpertNMS system. ExpertNMS provides comprehensive tools via an intuitive Graphical User Interface (GUI) for the operator to view the amount of bandwidth being utilized by CBR and CIR services, as well as how much bandwidth is available for best-effort services. Views are available for the outroutes, inroutes, and IQoS groups. Detailed views of bandwidth utilization per satellite router are also available.

This functionality extends to the VNO for a view of this portion of a network.



With these tools, operators can intelligently manage the QoS, optimize the existing bandwidth, and predict future growth and expansion.

Conclusion

The Hughes HX System provides an unparalleled capability and powerful tools to manage satellite bandwidth by utilizing Adaptive Coding and Modulation, Adaptive Inroute Selection, closed loop Uplink Power Control, etc., which when coupled with Traffic Management QoS features enables operators to squeeze maximum capacity from available spectrum at the lowest possible cost. For enterprises especially, the QoS capabilities of the HX System are critical for smooth operations and successful applications.

Proprietary Statement