GI General Instrument®

Multimedia Data Delivery
By Satellite and IP Multicasting

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1. Introduction

A dramatic change brought about with the advent of digital television is the conversion from an analog to a digital representation of the television spectrum. In the new digital world, data is easily and efficiently passed through from its source to destination in an unaltered fashion. As a result, datacasting is rapidly achieving parity with video and audio services in digital television systems.

Sources of data are expanding (Internet, streaming video and audio services, digital archives) along with the public's demand for more and varied information-based products. The wide and easily accessible "data pipe" provided by digital television has placed data on a similar level of importance with video and audio services to the home. As a result, datacasting has become the newest source of revenue-producing services for digital television programmers and distributors. This paper explores the distribution and delivery of Internet Protocol (IP) data services, and the role of digital satellite and digital cable systems in the delivery of these services from the programmer to the viewer.

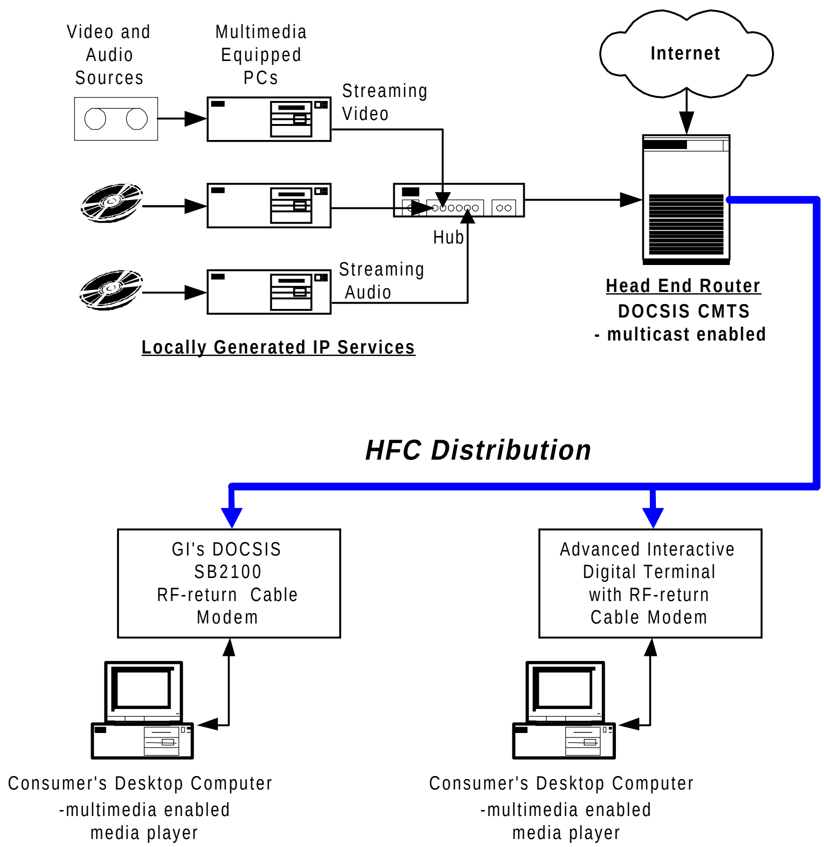
2. Internet Delivery

The high bandwidth available to homes over cable systems puts the cable operators in an especially good position to deliver Internet services to their subscribers. The introduction of cable modems provides cable subscribers with high speed Internet connections directly into the home. Subscribers can now experience a rich variety of multimedia graphics delivered with a higher quality-of-service than available through established terrestrial connections to the Internet. Additionally, the cable system offers a permanent connection to the Internet, which bypasses traditional telephone connections, and can be conducted simultaneously with IP telephony services offered by cable operators in the future. Immediate, uninterrupted and multimedia rich Internet service then becomes as friendly and compelling to the cable subscriber as the television services he currently enjoys from his cable operator.

Cable headends use Internet routers to provide a gateway for the cable system’s subscribers to reach Internet web sites. The connection to the Internet is suitable for downloading files as downloads do not have to occur in real time and can be routed to take advantage of the least congested paths through the Internet. But the result is a very bursty and jittery flow of data into the client computer, which represents a low quality of service for real-time data such as streaming audio and video. The client has to compensate for this with a considerable amount of buffering, which ultimately limits the variety and complexity of acceptable multimedia content.

Cable systems are in a position to overcome the Internet's limitations by creating their own web site with an attractive line up of downloadable and streaming data services for their subscribers. As the diagram below shows, these IP services can be generated locally using video and audio playback equipment feeding multi-media equipped PCs. These PCs could use software based computer applications for performing compression and IP encapsulation of the streaming data. These data streams could be delivered to subscriber's homes over cable systems equipped with Data Over Cable System Interface Specification (DOCSIS) cable modems and advanced set top terminals. The IP services can be treated as a separate service for PC users, or on equal parity with the other television and radio services in the digital program lineup.

Figure 1 Internet Services at Cable Headends

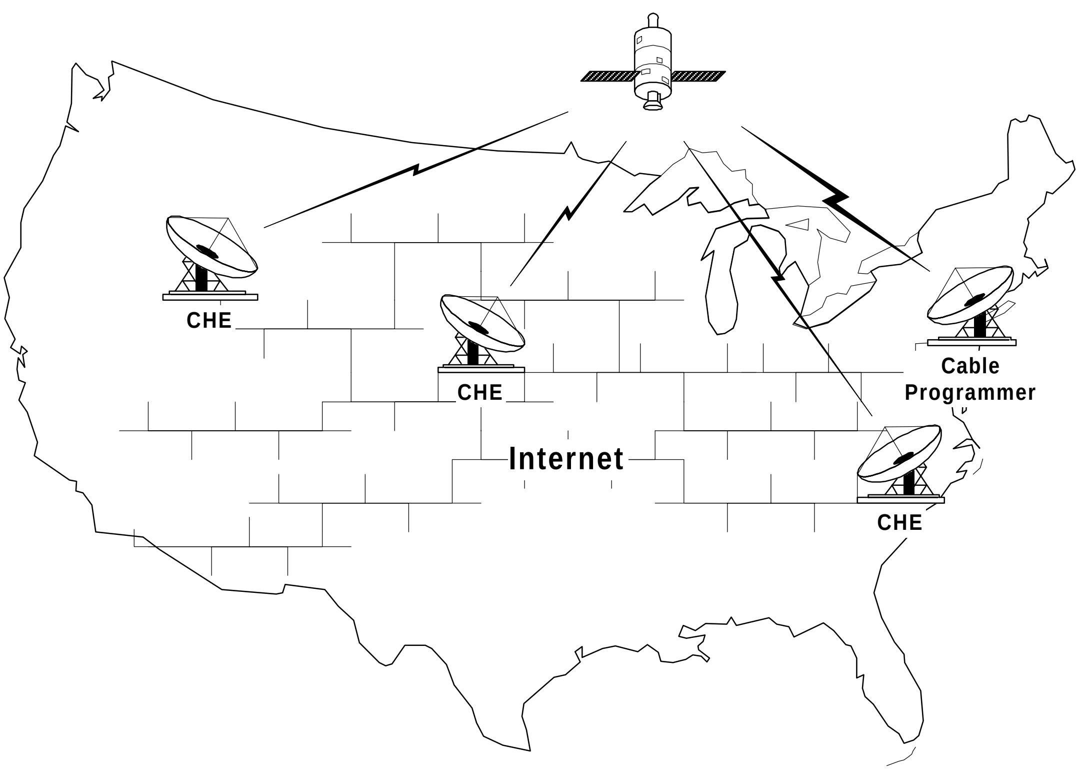


The capital investment and cost of producing local IP programming could be a burden to individual cable operators. While premium services, such as interactive gaming, could well be worth the investment, it would be much more economical if IP programming were centrally produced and distributed nationally to cable systems. But limitations to the quality-of-service over the Internet remain an obstacle to this model.

3. A New Hope

An alternative comes from the same programmers that already provide, via satellite, the vast majority of programming carried over cable systems today. Satellite delivery of IP data can bypass the router bottlenecks in the terrestrial Internet and deliver data directly to cable systems with a very high quality-of-service. The programmers could provide program related IP services to augment the viewing experience of their existing programs, or use data to offer an expanded range of programming options to properly equipped cable subscribers. This would allow the cable operator to further differentiate his broadband services from those of the narrowband Internet, and be a further incentive for his subscribers to upgrade their set top terminals and be able to participate in more premium services.

Figure 2 Satellite data delivery



3.1 IP Multicasting

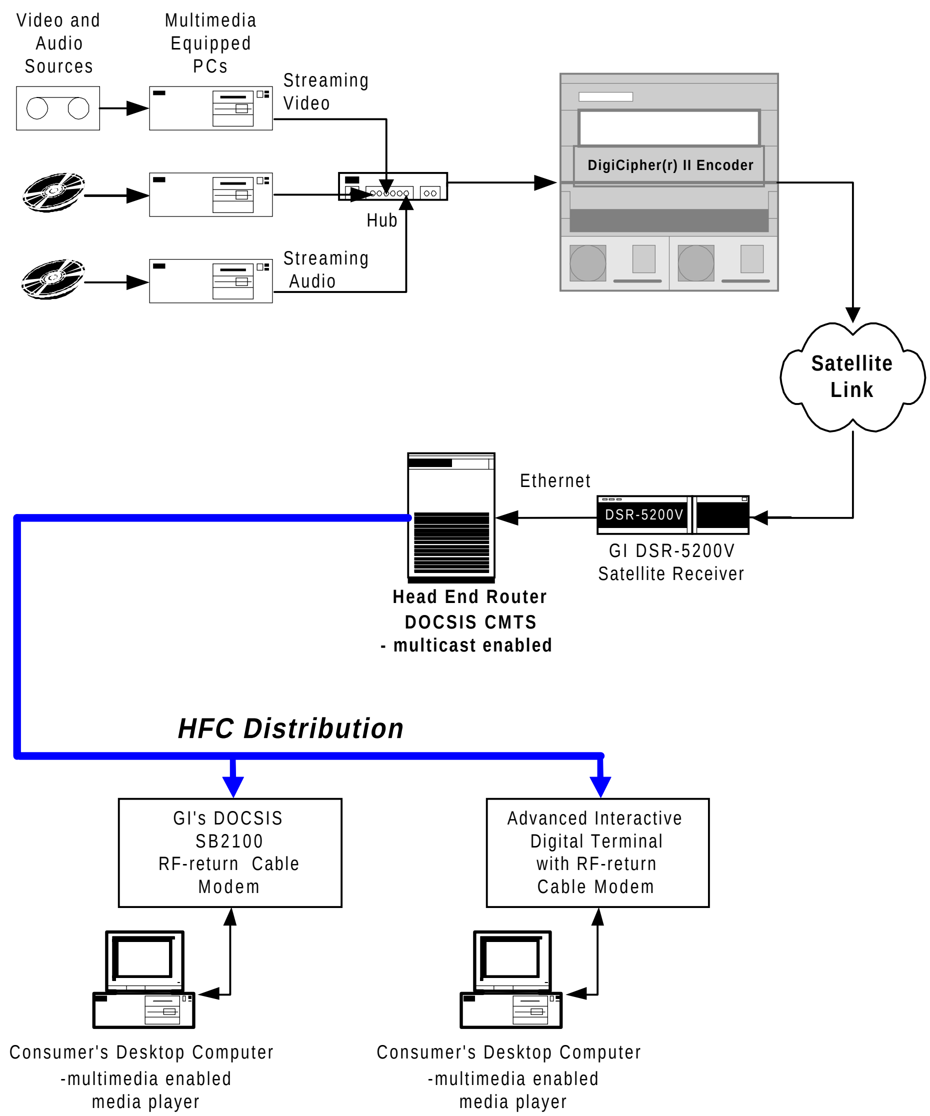
Satellite data delivery is capable of both high speed file transfer and streaming video and audio feeds. Digital cable systems may even offer the streaming feeds as another program listed in the subscribers' program guide. Therefore, it is likely that these feeds would be simultaneously accessed by multiple subscribers. Traditional IP networks establish an unicast connection between the headend router and each subscriber. Such simultaneous connections could rapidly consume even the great bandwidth available through cable modem systems. IP multicasting protocols are now available to overcome this problem.

IP multicasting differs from IP unicast in that a multicast enabled router can feed multiple clients with a single IP data stream. This avoids the multiplication of data streams that occurs with traditional IP unicast and allows the cable operator to deliver only one IP data stream per service to its subscribers. This means that the cable operators can concentrate their resources on delivering more data based services and less upon supporting duplication of those services.

Although IP multicasting can potentially be conducted over the Internet, there are still a number of technical issues involving the lack of multicast capable routers and conflicting IP multicast protocols that hamper the launch of multicast groups through the Internet. Smaller self-managed networks such as digital cable systems are in a better position to establish IP multicast routing and multicast groups, and satellite distribution is now emerging as an excellent way of delivering both television and IP data to those cable systems.

The diagram below shows how a multiplex of real time streaming video and audio programs can be delivered to cable subscribers over a combination of satellite distribution and cable modems. Video and audio sources can be compressed into a stream of IP data. This data stream can be carried via satellite to cable headend routers around the continent. This router is enabled to support distribution of each streaming video and audio service to its cable modem subscribers as separate IP multicast sessions.

Figure 3 Satellite distribution of IP services



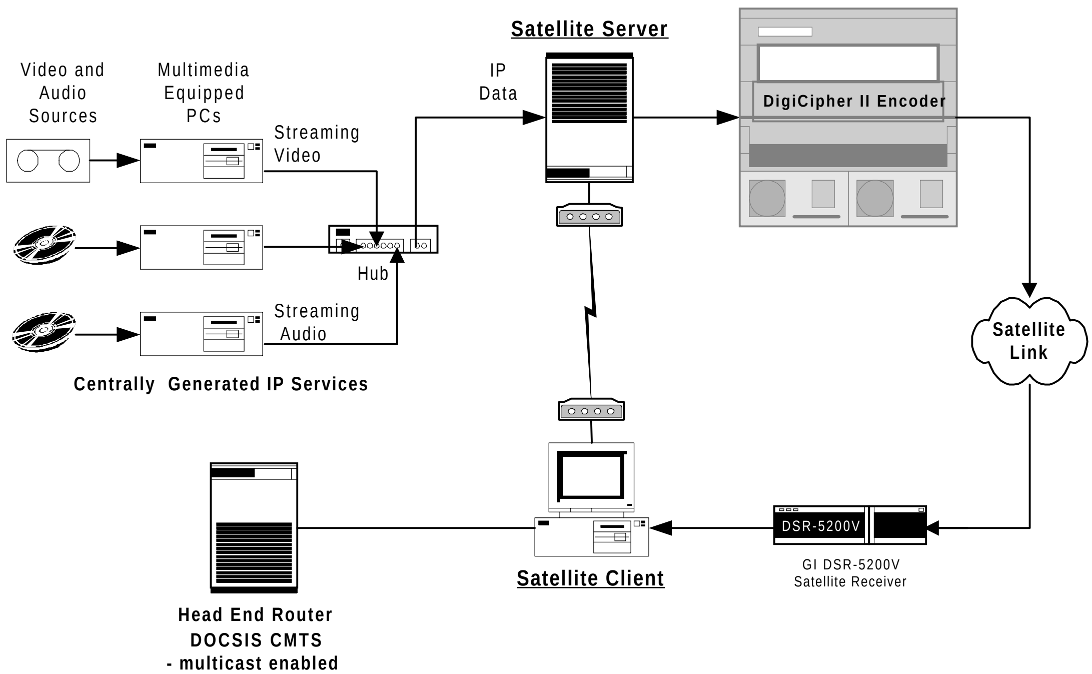
3.2 Reliable IP Transmission

Data file transfers are considered to be reliable when the receive site can detect erroneous blocks of data and request retransmissions of the erroneous blocks. This allows the receive site to build up a completely accurate file. This level of accuracy is not used in streaming video or audio as uncorrectable errors in transmission are simply concealed when they are presented to the viewer. But file transfers need to be reliable.

Reliability is supported over the satellite link by adding a Client and Server computer at each end of the satellite link. This allows the Clients to request retransmission of any erroneous data blocks from the Server as shown in the figure below. Reliable transmission is sustained by a combination of forward error correction in the satellite encoders and receivers, and further error checking by the Client computers at the end of the link. The satellite link utilizes channel coding techniques such as convolutional coding, randomization and interleaving to maintain a very high level of accuracy in the transmission of the data. The Server adds further error checking codes to the data files to allow the Client computer to detect any errors in the file transfer.

Reports of blocks received in error are stored in a log file by the Client. The Server periodically polls each of its Clients to determine which blocks need to be retransmitted, and if any of its Clients fail to respond to the poll. Only the data blocks that were not successfully received during the preceding transmission intervals are re-transmitted until the Clients receive all the blocks they need to complete error free files.

Figure 4 Reliable IP satellite transmission



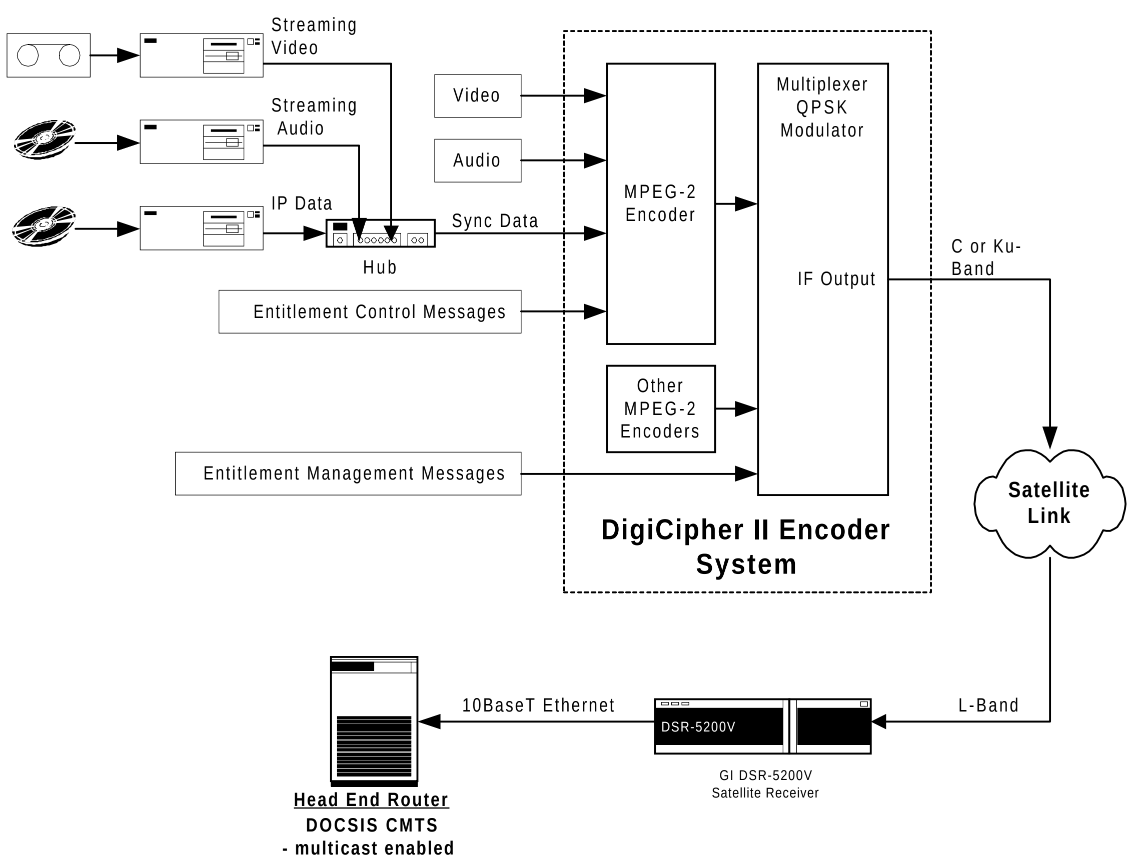
Once the files have been reliably received, they can be made available to the local multicast router. This provides the router with a reliable data source that it can call on if re-transmissions are required by any of its Clients. Clients may request IP connection with the router. The reliability of these connections is the responsibility of the headend router and its network. Reliable unicast connections are common using TCP/IP, and reliable multicast protocols are also becoming available.

4. IP Multicasting Service

Satellite delivery of real time video, audio and data is supported by General Instrument's MPEG-2 encoder systems. Each encoder system provides up to eight MPEG-2 television channel encoders in a single chassis, with multiplexers, encryption, modulators and redundancy. Each MPEG-2 encoder channel includes a data channel suitable for transmitting synchronous data up to 9 Mbps with a constant delay through the satellite link. This is referred to as isochronous data transmission. The high bit rate and constant delay provide the high quality of service desired for streaming data or large file downloads.

One or more IP streams can be carried in the isochronous data channel. As the figure below shows, the IP streams are first combined as Ethernet packets at a hub. Ethernet protocols already support interleaving multiple streams of Ethernet traffic. The resulting stream of Ethernet packets is converted to synchronous data at the input to the GI encoder. The synchronous data steam is encapsulated as an isochronous data service in the encoder's MPEG-2 transport stream, either as an element of a broader television service, or as a standalone data service with its own entry in the Program Association Table and its own Program Clock Reference.

Figure 5 DigiCipher® II Satellite Transmission System



Satellite transmission is managed under DigiCipher® II conditional access and encryption. This assures that only authorized receivers will be able to receive and decrypt the data. The encoder typically encrypts each elementary stream, including the isochronous data. The encoder also includes similarly encrypted

Entitlement Control Messages (ECMs) to provide properly authorized receivers with the keys that they will need to decrypt the data. The receiver then gets its authorizations from Entitlement Management Messages (EMMs). A separate EMM is generated, encrypted and transmitted to each of the receivers in the authorization list. Only the target receiver is capable of decrypting the EMM intended for it, so the EMM cannot be intercepted and used by unauthorized receivers. Once it is properly authorized, the receiver will be able to decrypt the ECM messages and then use the keys to decrypt the isochronous data stream.

The entire MPEG-2 transport stream including the encrypted video, audio and data streams is multiplexed with transport streams from the other MPEG-2 encoders in the same chassis, and the resulting MPEG-2 transport multiplex undergoes channel coding and QPSK modulation to prepare it for satellite transmission.

Reception of the desired isochronous data service can be performed by a number of General Instrument Integrated Receiver/Decoders (IRDs). Each of them feature conditional access and encryption, but the model DSR5200V has been developed with a 10BaseT Ethernet output for the isochronous data channel. Because most high speed modem systems support 10BaseT protocol (cable modems, etc.), it is possible to hand off such data at the high speed modem router as if it were locally generated.

For the consumer, media rich content can now be streamed to the home without concern of latency exceeding buffering capabilities. Equally important, by avoiding the Internet backbone, video resolution, audio fidelity and the number of simultaneous users can be significantly increased.