Datacasting with LMDS and MMDS Systems

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The creation of open network standards to facilitate datacasting, including unicast (point-to-point), multicast (point-to-multipoint) and broadcast, has resulted in the development of hub and client receiver technology that is both cost-effective and functional. The devices in use provide an exceptional means of distributing high-speed data in point to multipoint distribution systems over satellite, traditional television broadcast, cable television and terrestrial microwave systems. Each of these systems offers unique benefits and challenges. This discussion focuses on two types of terrestrial microwave platforms — local multipoint distribution systems (LMDS) and multichannel multipoint distribution systems (MMDS).

Datacasting technology

Datacasting technology is available using a variety of protocols that include, but are not limited to, ATM, frame relay, and multi protocol encapsulation (MPE). MPE is based on the ETSI EN 301 192 standards. The hub equipment used to perform the MPE function is referred to as an Internet Protocol (IP) to Digital Video Broadcasting (DVB) Gateway. The IP to DVB Gateway acts as a router, a gateway, an encapsulator and, in some cases, a quality-of-service (QoS) engine and a statistics logging device for billing purposes. The resulting output of the IP to DVB gateway is an MPEG transport stream that is fully compatible with the open DVB standards. Thus, the IP to DVB Gateway can be used directly, or multiplexed together with other MPEG transport streams (Figure 1).

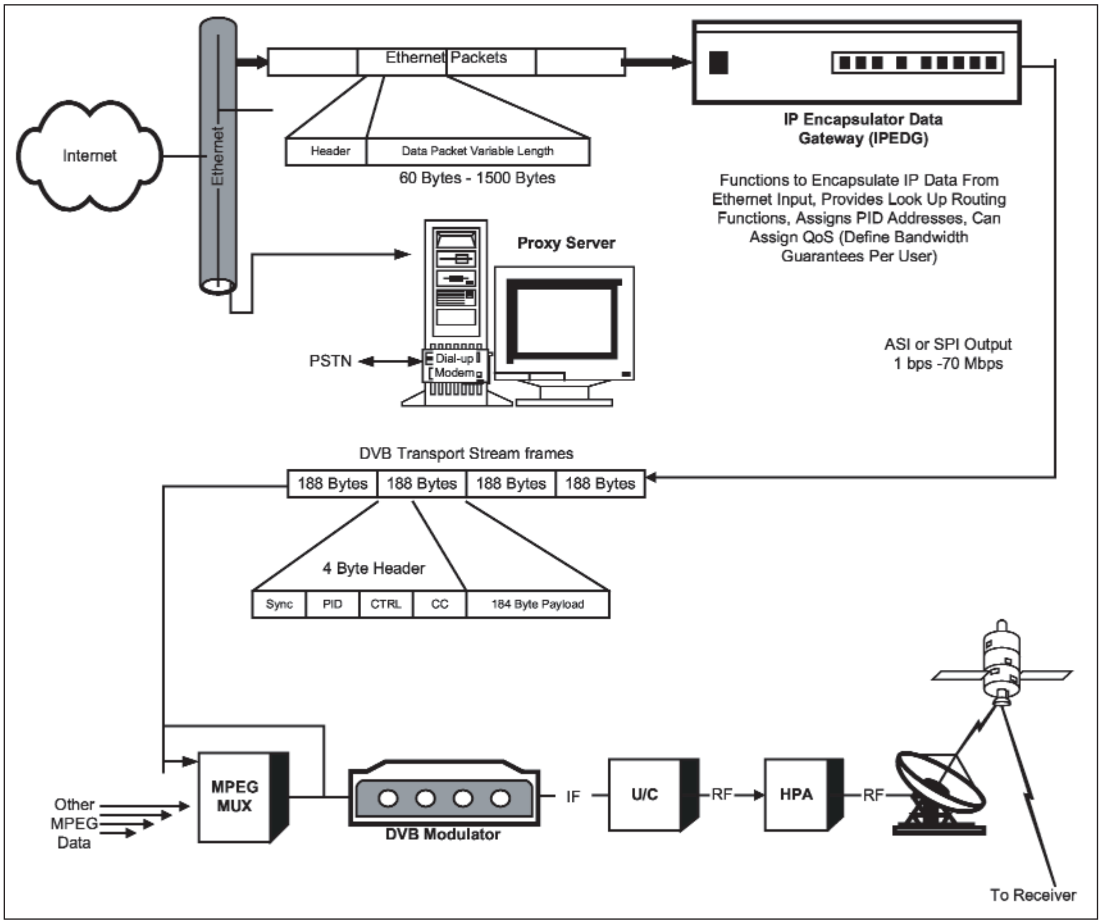
The receiver of the data transmission exploits the cost benefit of a widespread DVB open network architecture, resulting in very low-cost but high-performance data receivers for the DVB specified modulation techniques that include QPSK, 8PSK and 16/32/64/128/264 QAM. The important issue at hand is that the baseband digital architecture is the same, no matter which modulation technique is used.

MPE supports unicast, multicast and broadcast data transmissions. It offers exceptional bandwidth efficiency in the multicast and broadcast modes of transmission because the data is only transmitted one time, to a host of receiving clients. MPE systems can support one-way "pushing" of data, or two-way communications. For simplicity, only a one-way "push" system will be discussed in this article.

MPE and DVB standards are at the core of the baseband technology for datacasting over a wide range of transmission platforms. How can these standards be used in MMDS and LMDS transmission platforms?

The use of IP data encapsulation into an MPEG transport stream provides a cost- and performance-effective approach to multicasting data on a point-to-multipoint basis. Advanced encapsulation products provide a number of critical features to maximize hub and bandwidth efficiency. These include, but are not limited to:

- An advanced route-based design architecture supporting the network-centric operating paradigm.
- An integral QoS engine providing the means to both guarantee and limit data rates on a per route basis.
- A buffer status algorithm that provides a means to dynamically throttle the data from the multicast server on a route-by-route basis.



▲ **Figure 1. IP to DVB gateway functionality.**

In effect, this precludes the possibility of under or over flowing the input buffers. This allows excess capacity to be dynamically filled with productive data.
- Support for both SNMP and DCOM communications protocols for ease of integration with network management systems.

Another reason for the use of encapsulated data is the availability of cost-effective digital receivers in the form of PCI receiver cards with integral tuners and QAM demodulators.

The installation of the PCI card receivers provides the means for a direct multicast data transfer to the client PC. This data can then be used immediately or cached on the PC hard drive for instantaneous retrieval at the user's convenience.

MMDS and LMDS platform synopsis

MMDS and LMDS are both point-to-multipoint microwave systems that are licensed, usually on a basic trading area (BTA) basis. However, that is where the similarities end. The difference in the frequency bands of these systems has a crucial effect on the system design, capacity and usefulness for a datacasting application. Table 1 shows a basic comparison of these transmission platforms.

Let us consider MMDS first. In general, the favored cell architecture is a single, large macro-cell. While multicell deployments have been implemented, they are generally not efficient. The reason for this is twofold. The 2.5 GHz frequency band requires either large antennas, which are not well-received consumer client receivers, or smaller antennas with very broad antenna beams. Since practicality and cost supercede technical excellence, smaller, low-cost antennas are preferred. The consequence of such a choice is that multipath (reflections of the radiated energy from either the ground or other structures) is induced, due to reflections of the signal associated with broad antenna beams. This in turn requires that the modulation technique provides significant immunity to the effects of multipath.

Only three demodulator technologies are produced in sufficient volume to be cost-effective and also provide some immunity to multipath: 8VSB, COFDM (coded orthogonal frequency division multiplexing) and CATV demodulators using QAM. Both 8VSB and QAM use extensive equalization to counteract the multipath effects. The equalizers for 8VSB are continuing to be improved at this time but are not yet sufficiently mature to meet the requirements associated with these links. COFDM links, on the other hand, are available. They offer significant multipath immunity, and operate with lower E_b/N_0 requirements than QAM modulations. However, COFDM links do so with less spectral efficiency — that is, fewer bits/second/Hertz than higher order QAM modulation.

QAM demodulators use extensive equalization to overcome the multipath in CATV systems. However, since they were built for the CATV environment — a very high signal-to-noise environment — these demodu-

Parameter	MMDS	LMDS
Frequency band	2.5 to 2.7 GHz	28.5 to 29.5 + 31.0 to 31.3 GHz
Propagation characteristics	Good for medium range, line-of-sight, ≤50 miles Free space attenuation $\sim Kd^2$ (or ~6 dB/octave)	Good for short range, line-of-sight, ≤5 miles Free space attenuation $>Kd^2$ (or >6 db/octave)
Antenna characteristics	~11 times larger than equivalent LMDS antenna with same specs	~1/11th the size of an equivalent MMDS antenna with same specs
Since practicality dictates that antennas will be of approximately the same physical size	MMDS antennas will have less directivity (i.e., broader beam-widths) than LMDS antennas	LMDS antennas will have more directivity (i.e., narrower beamwidths) than MMDS antennas
Favored cell architecture	Single, large macrocell	Multiple, small microcells
Impact of cell architecture	Limited bandwidth availability due to no frequency reuse	Large bandwidth available, which can effectively be increased by decreasing cell size
Ability to support two-way system architecture	Limited due to bandwidth, antenna characteristics and propagation characteristics	Well suited due to small cell size, large available bandwidth and highly directive antennas in reasonably small sized
Link pathology	Long range and broad antenna beams ensures significant multipath	Short range and highly directive antennas mean little or no multipath
Modulation preference	High order modulation producing more bits per second per hertz, with a strong multipath immunity (e.g., DVB–C QAM or COFDM modulations)	Lower order modulations to minimize Eb/N_0 requirements to minimize self interference (e.g., DVB Q/8PSK modulations)

▲ **Table 1. Link pathologies of LMDS and MMDS.**

lators incorporate only Reed-Solomon block decoding, foregoing the benefits that concatenated forward error correction (FEC) coding provides in dramatically reducing the threshold E_b/N_0 requirements for the demodulator. Wireless systems, on the other hand, are always limited by noise. Therefore, the use of QAM modulation in the MMDS environment imposes very high S/N and corresponding E_b/N_0 requirements on the system. These high S/N requirements produce dramatic self-interference in a cellular environment where some level of frequency reuse is the justification of a cellular deployment. The use of higher order QAM modulation effectively precludes the use of a cellular MMDS deployment and encourages a single macro-cell architecture.

In the single cell MMDS deployment, the available bandwidth is limited to the frequency band licensed, which is equal to or less than 200 MHz total. Using this limited bandwidth for two-way, interactive Internet access is certainly feasible, but does not produce broadband access to any reasonably sized population base. However, the use of datacasting, which exploits the multiplying effect of data multicast and broadcast, can provide a cost-effective and easily deployed model.

The MMDS model described is dramatically affected by the combination of bandwidth limitations, propagation characteristics and the resulting impact on preferred modulation type. The LMDS environment has similar cause and effect characteristics, but with a clearly different conclusion.

LMDS licenses are, like MMDS, issued on a BTA basis. The “A” licenses provide 1.15 GHz of bandwidth in the 28 to 31 GHz frequency band. The “B” licenses provide a mere 150 MHz of bandwidth. Operation in this frequency is clearly “line-of-sight,” with free space attenuation being further increased by atmospheric absorption due to moisture and pollutants. This characteristic is actually beneficial in deploying a cellular infrastructure as it helps to reduce cell-to-cell interference.

The use of the 28 to 30 GHz range adds another critical feature to system design. The high frequency allows for the design and construction of small antennas with excellent directivity. The ability to use highly directive antennas is one of the key factors to reducing multipath. The reduction or effective elimination of multipath provides the option to select more energy-efficient modulation types, without the need for extensive equalization. DVB-QPSK is an ideal choice for modulation because it provides very low E_b/N_0 threshold requirements, is supported by mass-produced, ASIC-based demodulators and promotes the most productive frequency reuse plan for cellular deployments.

LMDS has significant bandwidth, propagation characteristics favorable to cellular infrastructures and multipath characteristics that can be controlled by design. Deploying such systems on a cellular basis provides the means of effectively multiplying the available bandwidth by the number of cells deployed and allowed for unlimited bandwidth. Therefore, LMDS systems have been designed as two-way communications systems incorporating either frame relay or ATM switching technology.

These systems provide high performance and can be rapidly deployed. The drawback is that they are expensive on a per subscriber basis due to the complex switching technology and the cost of the power amplifier for the return link.

Reducing the cost of the subscriber terminal is partially achieved by limiting the power output of the linear amplifier used for the return link. The power limitation translates to an effective operational cell radius of operation that is most commonly 2.5 miles or less. The limited distance between the hub and the client receiver further contributes to the control of multi-path and the expansion of available bandwidth.

It would appear that LMDS has all of the benefits. Regrettably, they are achieved at some significant cost on a per subscriber basis due to the cost of two-way terminal equipment. An overlay of a point-to-multipoint service, in addition to the existing two-way infrastructure provides a low cost means of expanding subscribers with an additional tier of service.

In LMDS, like in MMDS, the use of IP encapsulated data allows for the use of low-cost receivers based upon the DVB-QPSK products commonly used in satellite transmission systems. The hub equipment, i.e., the site and the transmission equipment, is assumed to be present. All that needs to be added to the hub is an IP to DVB gateway and a multicast data server. On the client side, the standard antenna with a LNB (low noise block) downconverter, downcoverting the 28 GHz to an L-band (950 to 2150 MHz) IF frequency, is standard equipment for the traditional deployments. Using a common antenna and adding a low-cost PCI based receiver card can provide the same service opportunities as in the MMDS multicast case. Additionally, it provides an effective path to identifying future customers for the less costly, higher-performance two-way communications capability. ■

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Rene Savalle also contributed to this article. With more than 28 years of experience in the satellite and communications industries, he serves as the primary contact and sales director for Login Innovations' data broadcasting product line.

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