

DVB (Digital Video Broadcast) vs. iDirect Technology

DVB Technology

Digital Video Broadcast (DVB) is a satellite-based standard that was primarily designed to use in broadcast video applications. The standard has been widely adopted due to its simplicity, easily available chipsets, and cost. DVB based technology is widely deployed and understood by most network operators. DVB was primarily designed for one way broadcast of video and MPEG traffic. Recently a new standard DVB-RCS (Return Channel via Satellite) was completed to allow for a standard based return channel for two-way traffic. The intent of the open standard is to accelerate economies of scale, thereby generating lower-cost solutions and opening the market in a shorter timeframe than could be possible with competing proprietary solutions.

Technology

DVB standard for the forward or broadcast channel has the following technical characteristics,

- MPEG frame for transporting video and data
- RSV (Reed-Solomon Viterbi) based Forward Error Correction
- Very high bandwidth on the outbound

DVB-RCS standard has the following characteristics,

- TDMA based inroutes
- MPEG frame for transporting data
- Also supports ATM cells for transporting data

DVB standard based systems are advanced and interoperate well on the outbound channel between different vendor equipment. DVB-RCS for the return channel is another story. The standard only provides for the basic interoperability between different vendors. For any enhanced services, the interoperability is lacking to say the least.

The standard does not guarantee basic interoperability (e.g. TDMA slot sizes, # of inroutes, hopping vs. static frequencies, frame sizes, code rates are all variable). In theory two vendors could design infinitely adjustable implementations of the specification. In reality, they would have to actively engage each other and support a set of interoperable modes.

Advantages of DVB based system:

- High bandwidth outbound or broadcast
- Designed and built for Video Broadcast
- Lower Cost of Remote Terminals

Disadvantages of DVB based system:

- Generally Power-Limited satellite requirement
- Very inefficient when use of transponder capacity
- Not designed for TCP/IP traffic. IP is encapsulated within MPEG
- Very high Hub equipment cost

Advantages of DVB-RCS based system:

- Potential interoperability between multiple vendors
- Potentially lower cost of modems

Disadvantages of DVB-RCS based system:

- Interoperability between multiple vendors limits functionality
- Typically implemented with RSV FEC which is not very efficient
- TDMA protocol used is typically slotted-aloha

iDirect Technology

iDirect has pioneered TCP/IP over satellite technology in the industry to ensure the most efficient use of satellite bandwidth. As demand for IP over satellite continues to grow more Network Operators would want to start offering IP services over satellite. iDirect technology is designed to allow Network Operators implement these networks at a much lower cost, at the same time provide a business class service with all the TCP/IP enhancements over satellite.

Technology:

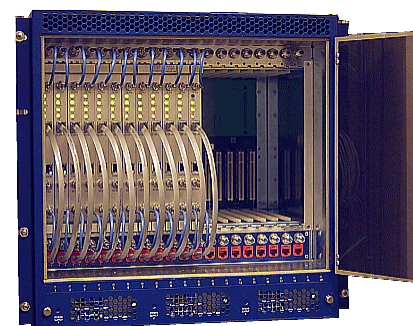
iDirect Outbound has the following technical characteristics,

- TDM Based Broadcast
- Up to 11.5 Mbps Channel Rate
- Primarily Bandwidth Limited Implementation
- Turbo Product Codes (TPC) FEC
- Lower E_b/N_0 for 10^{-9} BER when compared to RSV
- iDirect Frame Format optimized for TCP/IP



iDirect Inbound or Return Channel has the following technical characteristics,

- Enhanced Dynamic TDMA Technology
- Up to 5.75 Mbps Channel Rate
- Primarily Bandwidth Limited Implementation
- Turbo Product Codes (TPC) FEC
- Lower E_b/N_0 for 10^{-9} BER when compared to RSV
- iDirect Frame Format optimized for TCP/IP
- Dedicated bandwidth per VSAT
- Extremely fast dynamic allocation algorithms



Advantages of iDirect Technology

- Primarily Bandwidth limited, thus much lower service costs
- Extremely responsive TDMA channels
- Queue depth checked 5 times/sec
- All remotes have a minimum CIR
- Multiple-inroutes Network Capability
- Frequency Hopping Capability – Dynamically Assigned based on demand
- Very scalable hub equipment, with multiple network support within a chassis

Advantages of iDirect Hub Technology

- Very compact (1/6th the size) of comparable technologies
- Extremely scalable
- Support for multiple networks within one chassis
- Very cost competitive
- Carrier Class – Fully Redundant with Hot-Swap capability

Other iDirect Solutions Benefits

- TCP Acceleration in BOTH directions
- TCP Session Initiation Acceleration in BOTH directions
- QoS in the BOTH direction
- Rate Limiting Capability in BOTH directions
- Committed Information Rate Capability
- Controlled Over-subscription Capability
- Fast “First-Click” Response
- DHCP/NAT/Local DNS Caching Capability
- Built-in 3DES Link Encryption Capability

DVB vs. iDirect – IP Efficiency Comparison

DVB frame format uses MPEG for broadcasting video. IP over DVB has to be encapsulated within an MPEG frame to be transported over DVB. IP packets must be segmented into MPEG 188 byte cells which further decreasing efficiency. This is a consequence of using a system optimized for digital video to transport IP packets. A maximum sized 1500-byte Ethernet packet has to be segmented into 8 or more MPEG cells. The iDirect solution has no such constraint. Transport cells are sized variably depending on the size of the IP packet instead of having to conform to fixed sized cells.

This provides a much better throughput efficiency over an iDirect Network. As an example, over a 500 KHz satellite capacity, with an iDirect solution one can get a TCP/IP throughput of 530 kbps. With the same satellite capacity over a DVB network, the TCP/IP throughput is 385 kbps.

Case Study:

On 8 MHz of satellite capacity, using QPSK and some guard band and RSV Coding Rate $\frac{3}{4}$, with DVB one will get a data rate of 7.7Mbps, but the actual IP throughput of 75-80%. **The IP throughput will be around 5.7-6.1 Mbps.**

Over the same satellite capacity the iDirect solution gives an **IP throughput of 8.65 Mbps**

DVB vs. iDirect – Satellite Transponder Capacity Usage

DVB based systems use concatenated Reed Solomon and Viterbi for its FEC. iDirect uses Turbo Product Codes (TPC) FEC for its system. iDirect systems operate at E_b/N_o 's approximately 1.5 dB lower than DVB based competitors to deliver 10^{-9} BER performance. This reduced requirement allows an operator to use lower power on the satellite thus reducing overall cost of the system. This allows the network operator to provide a more cost-competitive solution that provides a better TCP/IP performance over satellite.

Case Study:

BER performance of iDirect 4k TPC coder is equivalent to the Reed Solomon / Viterbi 3/4 code. (TPC is actually slightly better by about 1/4 dB). In addition, an RSV based system requires about 1.5 dB more power to maintain a BER of 10^{-9} (This is critical when having TCP/IP over satellite).

Network Size:

Channel Rate: 5 Mbps
 Encoding: QPSK (2 bits/symbol)

RSV:

RS/Viterbi $\frac{3}{4}$ Code Rate: 0.691
 User Data: 5 Mbps * 0.691 = 3,455,000 bps
 Satellite Capacity: 2.5 Mhz
 Power Equiv. BW (+1.5 dB): 3.54 Mhz (To Provide Equivalent Quality as iDirect TPC)

TPC:

TPC Code Rate: 0.793
 User Data: 5 Mbps * 0.793 = 3,965,000 bps
 Satellite Capacity: 2.5 Mhz

If we consider a typical rate of \$5.00 per kHz per month.

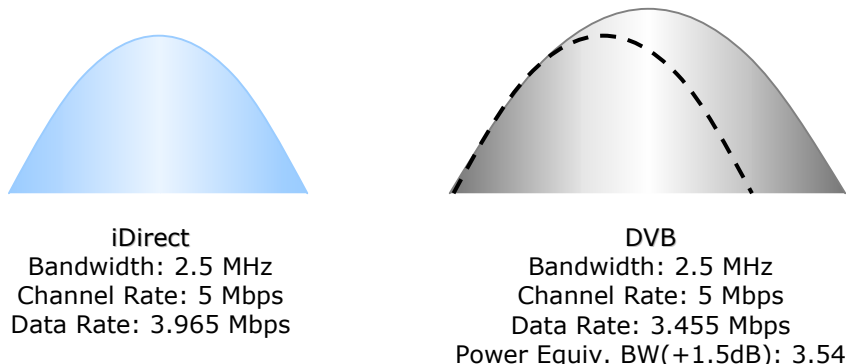
Comparison 1: Code Rate Efficiency and Usable Bit Rate

The coding efficiency of an iDirect system is significantly better than the competitors RSV based systems. From the above calculations it can be clearly shown that the iDirect system has 14.76% higher data throughput than the competitors.

3,965,000 – 3,455,000 = 510,000 extra user bits for same transponder capacity (14.76% more)

Comparison 2: Cost of satellite segment

RSV based system requires about 1.5 dB more power, than an iDirect TPC system, to maintain a BER of 10^{-9} . This BER performance is critical for a system with TCP/IP traffic. TCP/IP is very sensitive to BER performance and throughputs will vary significantly if a low BER is not maintained. To achieve the same BER levels of an iDirect system, competitors RSV based systems need about 1.5 dB additional power.



Thus the total additional bandwidth required by DVB based system is 1.04 Mhz.

Additional cost per month for a DVB based system is \$5,200.00 / Month or \$62,400.00 / Year

Comparison 3: Data on equivalent bandwidth

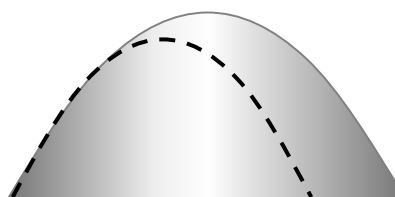
Another way of looking at this is, how much more data bits will one get when using the transponder capacity required by an RSV based system, by implementing an iDirect TPC system.

From the above example if one had 3.54 MHz of satellite capacity, using the iDirect system one will get 5,600,000 bps of user data rate.

This equals $(5,600,000 - 3,455,000) / 3,455,000 = 2,145,000$ bps or **62% more data**.



iDirect
 Bandwidth: 3.54 MHz
 Channel Rate: 7.08 Mbps
 Data Rate: 5.6 Mbps



DVB
 Bandwidth: 2.5 MHz
 Channel Rate: 5 Mbps
 Data Rate: 3.455 Mbps
 Power Equiv. BW(+1.5dB): 3.54 MHz

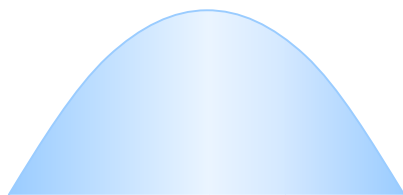
Comparison 4: Actual IP Throughput on Equivalent Bandwidth

IP throughputs over a DVB based system are typically about 80% of the user data rate. In the above example, the actual IP throughput over the DVB based system is $3,455,000 * 0.80 = 2,720,000$ bps.

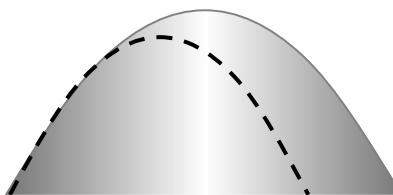
IP throughputs through the iDirect system are close to 95% of the data rate. For the above example, the IP throughput through an iDirect system would be 5,333,000. When compared to the DVB solution, the total increase in data through the systems is an **additional 96%** or a difference of **2,613,000 bps of IP data**.

Conclusion:

Based on the above case study, the difference in cost for implementing a network using an iDirect solution when compared to DVB based system is significant. This allows a Network Operator to lower



iDirect
 Bandwidth: 3.54 MHz
 Channel Rate: 7.08 Mbps
 Data Rate: 5.6 Mbps
 IP Throughput: 5.33 Mbps



DVB
 Bandwidth: 2.5 MHz
 Channel Rate: 5 Mbps
 Data Rate: 3.455 Mbps
 Power Equiv. BW(+1.5dB): 3.54 MHz
 IP Throughput: 2.72 Mbps

their service costs and provide a more efficient system. An iDirect solution not only uses the transponder capacity more efficiently, it also increases the actual throughput of TCP/IP dramatically. More importantly, an iDirect network provides a much better performance, which increases customer satisfaction and customer retention.

In addition, most TDMA systems use Slotted-Aloha protocol over the return channel. Throughput performance of slotted ALOHA is efficient until the channel utilization exceeds 36.8% at which point the number of collisions increases dramatically and there is a snowball effect where none of the users get good throughput on the channel.

The iDirect Deterministic-TDMA (D-TDMA) system provides guaranteed bandwidth to every user in the system according to the Quality of Service parameters allocated to the user. iDirect's advanced Demand Assignment algorithm ensures that data gets through with minimal latency even when the channel utilization is approaching 100%.

Forward Error Correction (FEC): General Comments

Fundamental information theory as it applies to digital communication tells us that a system can be designed to deliver error free digital information even in the presence of noise if sufficient power and bandwidth are used on a given channel. Therefore, we can increase the performance of a satellite channel by increasing the dish size, increasing the power of the transmitter, and by increasing the bandwidth of the channel. In a practical VSAT network, the user's budget tends to dictate these costs and the system designer is forced to work within these budget constraints. FEC enables us to use some of the bandwidth allotted to the user for redundant coding information which can be used at the receiver to detect and correct errors that occurred during transmission.

A good FEC code reduces the channel efficiency by an acceptable amount and delivers the equivalent error rate performance of an uncoded channel operating at a much higher Signal-to-Noise Ratio (SNR). This concept is known as coding gain. Coding gain is measured in dB and is equal to the difference in SNR between an FEC coded channel and an uncoded channel operating at a given bit error rate. Good FEC coding equates directly to smaller dish sizes and smaller power amplifiers. Or, put another way, for a fixed dish size and power amplifier, good FEC increases the amount of error free information that can be delivered over a given channel. Good FEC also adds insurance against signal loss due to rain fades.

Turbo Codes were invented in 1992. Turbo Product Codes (TPC) were introduced in 1998 and provide a very cost efficient implementation of the Turbo Coding concept. The prior state of the art in FEC dates back to the 1960s with Viterbi and Reed Solomon FEC coding which may be used independently or concatenated (RSV). The widely used DVB standard employs the older RSV scheme because it was defined when Turbo Codes were not yet commercialized. There is talk among the DVB standards group of adopting a Turbo Coding scheme but this is still in the initial stages. Once the next DVB standard is defined, it will take time for new chipsets to become available and a scheme will have to be devised to replace existing customer hardware with new turbo-code capable hardware.

iDirect has been producing modems with Turbo Coding since 1999.

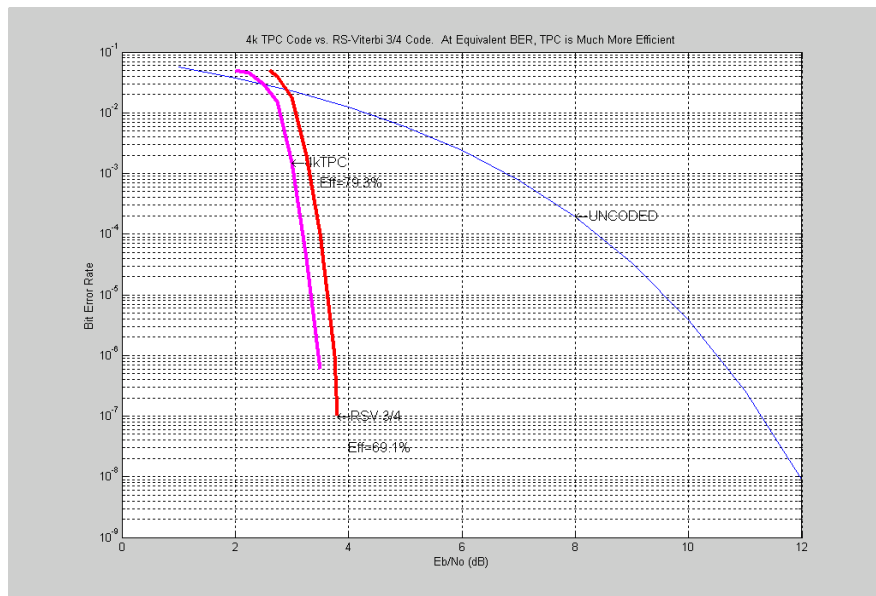


Figure 1 This figure illustrates the efficiency advantage of TPC codes. The purple trace is the TPC 4k block code and the red trace is the RSV code using RS(204,188) concatenated with Viterbi Rate $\frac{3}{4}$. The error correction performance is roughly equal (TPC is slightly better) but the efficiency of the TPC code is much greater so you can send more user bits while maintaining the same BER performance.

ALOHA vs. SLOTTED ALOHA vs. iDirect Deterministic TDMA (D-TDMA)

ALOHA is a multiple access technique that was invented to simplify network management systems by allowing any user to burst data in at any time on the same channel. If the channel utilization is very low,

the probability that two users will both transmit at the same time is also very low, therefore, most of the messages are received uncorrupted. However, if two users burst at the same time, a collision occurs and neither message is received correctly. If the user doesn't get an acknowledgement of his message, he waits a random amount of time (sometimes called the ALOHA backoff) and then he tries again. It turns out that using the ALOHA scheme gives good results until the percentage of channel utilization exceeds 18.4%. At that point, the number of collisions increases dramatically and there is a snowball effect where none of the users get good throughput on the channel.

To combat this problem, ALOHA was modified by synchronizing all users to a common clock and allowing them to burst during fixed time slots if they have data to send. This is called Slotted ALOHA and it prevents the situation where data bursts are corrupted due to partial overlapping of another burst. Throughput performance of slotted ALOHA is efficient until the channel utilization exceeds 36.8% at which point, the same snowball effect occurs.

The iDirect Deterministic-TDMA (D-TDMA) system provides guaranteed bandwidth to every user in the system according to the Quality of Service parameters allocated to the user. Once a slot is allocated to a user, no one else will use that slot. iDirect's advanced Demand Assignment algorithm is tightly coupled to its QoS algorithm and together, they ensure that data gets through with minimal latency even when the channel utilization is approaching 100%.