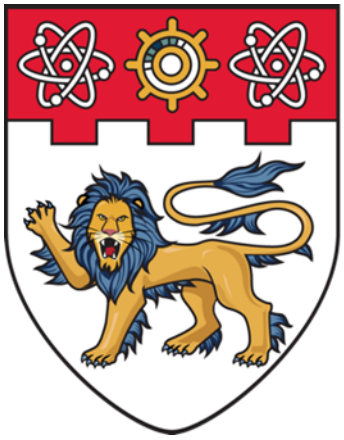

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EE4188 WIRELESS COMMUNICATIONS

REPORT: DIRECT-TO-HOME SATELLITE TV

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1. Introduction

Today, television is an integral part of day to day life for most people around the world. Billions of people tune in to their favourite channels every day. It is one of the most widely used platforms for entertainment, news, sports, advertising etc. One cannot help but wonder how such a humongous system works? How can everyone across the world watch a live sports event simultaneously?

The answers to this lie in Satellite broadcast technology, which first enabled live feeds to reach across the world. Television signals throughout history have primarily been broadcasted using 4 methods: Terrestrial Broadcast, Cable Television, Satellite DTH and Internet TV.

Of these, terrestrial broadcast is the oldest method of broadcasting television signals. It uses an earth based transmitter to transmit TV signals, received by TV sets directly with their antenna. It was the most popular method of TV broadcasting since the 1950's but is becoming less popular these days.

Cable TV, on the other hand uses coaxial cables to deliver RF signals with video and audio modulated in them to TV sets. It is being used to this day, and has undergone a plethora of changes over time.

Satellite Direct to Home TV, involves the use of Satellites to directly beam in the TV signals to small dishes set up at a subscriber's home, which then delivers the signal to the TV sets.

Internet TV or IPTV is the newest of the methods of TV broadcast and involves the use of the internet to deliver TV content.

1.1 The Dawn of the Satellite Era

The first satellite TV transmission were made in western Europe and North America, in 1st July 1962 via the Telstar satellite. It enabled people from both sides of the Atlantic to view each other's programmes, something which was not possible through terrestrial TV signals due to

the limited range of Line of Sight signals. Though this broadcast was not a DTH broadcast and required large ground stations to receive the satellite signals, it was the first use of a satellite to broadcast TV and served as a precursor to later DTH systems.

A huge leap in satellite technology was required to make DTH feasible. One of the major problems faced was in making powerful satellite transponders required to make small parabolic dishes (to be installed in houses) receive a strong signal. It was not until the late 1970's and early 1980's that DTH satellite TV started being used in households, with the first DTH satellites being the ATS-6 launched by NASA in 1974 and the Ekran1 in the USSR in 1976.

These initial systems had their own problems as the dishes were still relatively large (3-4 m) and were very expensive to set up. They used the C-band for their signals. Later on, the Ku-band started being used and is still in use. A detailed comparison of these two bands are included in the following sections of this report.

Also, early systems sent analog signals over the satellites. Digital chips were not fast enough yet to enable the use of digital signals for transmission. But with rapid advances in technology over the next decade, digital DTH signals became feasible and they were fairly common in the late 1990's. Digitisation helped provide multiple benefits, namely: smaller dish size, much higher number of channels available due to more usage of spectrum made possible and the potential for HD TV.

Digitisation led to rapid growth of DTH throughout the world. Today, DTH services are used throughout the world and are seen as a convenient alternative to cable-based systems. Competition in the industry and technological advancements has made it possible to view hundreds of channels, including HD channels using a small dish (one metre in diameter) at any place in the world at a very low cost. It is very popular in many parts of the world.

2. Architecture and Implementation

Most DTH systems today use digitally modulated signals in the Ku-band for their service. A typical DTH satellite TV system uses a DVB-S2 based system recommended by the International Telecommunications Union and it has the following three main architecture.

2.1 Broadcast Station/ Uplink Antenna

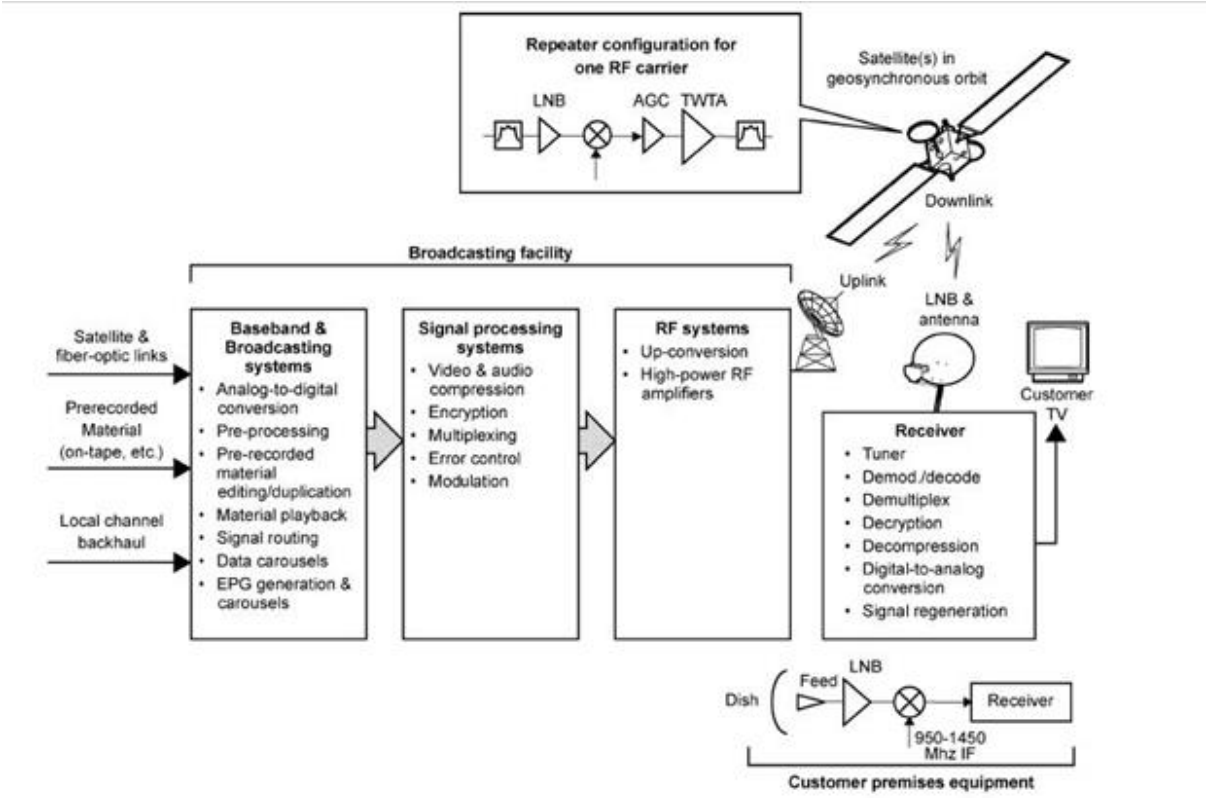

Figure 1: All digital multichannel satellite DTH system [1]

The broadcasting station receives all the broadcasting channels via fibre or directly from satellites using large dishes. The contents to be broadcasted undergoes the following steps:

1. **Compression**: The received channel /data streams from all sources are first converted to digital format and then compressed using algorithms such as MPEG-2 (older) or MPEG-4. This is very important as the uncompressed channels occupy a lot of bandwidth of around 270 Mbps and compressing them reduces it to around 3-10 Mbps.

Hence, it helps fit a higher number of channels and is a key feature of satellite DTH broadcasts.

2. **Stream Multiplexing**: These compressed signals from different channels streams are then multiplexed digitally into a single MPEG transport scheme. This is basically statistical multiplexing of the different channels data streams. Statistical multiplexing is demand based allocation of bandwidth to multiple different data streams and is one of the most efficient multiplexing techniques available. In earlier days, when analog TV signals were broadcasted using satellite, multiple channels per carrier (MCPC) was used to multiplex the signals.
3. **Addition of Error correction codes**: Forward Error Correction Coding (FEC) is used in the DTH signals to help add some redundancy to the signal making it more noise tolerant. A code, Bose-Chaudhuri-Hcquengham (BCH), concatenated with Low Density Parity Check correction codes are used as the standard FEC in the new DVB-S2 standard for digital satellite TV broadcast.

4. **Encryption**: The DTH signal is encrypted using a variety of different techniques, depending on the DTH operator. Common encryption algorithms used includes DCII and VideoGuard. These are symmetric key techniques and are difficult to crack. They are used to ensure that only paying users are able to access and view the TV channels being broadcasted.

5. **Modulation**: In modern systems, digital modulation is used to transmit the signal. Usually, QPSK and 8-PSK are used for modulating the signal. In certain applications, 16-APSK and 32-APSK modulation schemes are also used.

2.2 Geostationary Satellite

The signal sent by the ground broadcasting station is received by a geostationary satellite. A geostationary satellite is one which always remains at the same position with respect to the

earth. This is a very useful property for DTH broadcasts as all the receiving dishes need to be oriented only once during the initial setup, pointing towards the geostationary satellite.

A single geostationary satellite can be used to effectively broadcast to areas as large as a continent such as Europe and North America. The satellite uses RF Transponders to re-broadcast the received signal. Most contemporary systems broadcast using the Ku-band. The satellite itself is powered by a large number of solar panels and uses the power generated to send out a strong signal which can be received and demodulated using small household dishes.

2.3 Household Dish and Set Top Box

- The end user needs just a small parabolic dish of a size around 30-40 cm to receive a sufficiently strong signal thanks to the Ku band being used and the powerful transponders in today's satellites.
- The parabolic dish reflects the signal onto the focal point of the dish which has the "feed horn". The feed horn is a waveguide which leads the signal to a Low Noise Block down converter (LNB).
- The LNB downconverts it to an intermediate frequency (L band) and amplifies the signal received. Usually, the Ku band signal (12-18 Ghz) is downconverted to around a 1 GHz signal.
- This is then sent to the set top box for further demodulation. The down conversion before sending to the set top box is required because transmitting the high frequency received signal for even a short distance would require expensive waveguides.
- The set top box then receives the signal via co-axial cables and demodulates, decrypts and decompresses it. This is done by the Set Top box.
- The unique subscriber card in each Set to box is used to decrypt the signal according to the users' subscription plan. Many set top boxes also provide the facility to record and store TV programmes via DVR.

3. Statistics and Comparisons

3.1 Characteristics of DTH

Table 1: Metrics and their Corresponding Values of DTH [2]

Metric	Typical values
Frequency Band used	Mostly Ku band (12-18 GHz) C band (4-8 GHz) was used in the past
Channel bandwidth	~36 Mhz/Transponder, different number of transponders in each satellite
Minimum carrier to noise ratio	-2.4 dB
Data Modulation	QPSK and 8-PSK
Data rate	~60 Mbps per Transponder
Typical number of channels	500+ SD and 100+ HD
Error Correcting coding	LDPC codes
Encryption	DCII, VideoGuard proprietary algorithms
Range	Have huge LOS range due to their height >1000 km for 1 satellite
Typical transmitter power level	For an Indian DTH satellite- INSAT 4A- 48 dbW~64 kW

(EIRP- Effective Radiated power)	A European DTH Satellite- Astra 3B- 52 dbW~158.4 kW

3.2 C Band VS Ku Band

Table 2: Comparison between C Band and Ku Band [3]

C Band	**Ku Band**
• Frequency range is 3.7-4.2 GHz • Have longer wavelengths compared to Ku Band waves • Prime focus dishes are used to receive C band frequencies • Less disturbance from heavy rain fade • Cheaper bandwidth • Possible interference from microwave links	• Frequency range is 11.7-12.2 GHz • Shorter wavelengths compared to C band waves • Offset dishes are used to receive Ku band frequencies • Sensitive to heavy rain fade • Operates with smaller satellite dish → cheaper and easier installation • Needs less power

3.3 Analog VS Digital TV

Table 3: Comparison between analog and digital TV [4]

	Analog	**Digital**
Signal	Analog signal is a continuous signal which represents physical measurements.	Digital signals are discrete time signals generated by digital modulation.
Waves	Denoted by sine waves	Denoted by square waves
Representation	Uses continuous range of values to represent information	Uses discrete or discontinuous values to represent information
Example	Human voice in air, analog electronic devices	Computers, CDs, DVDs, and other digital electronic devices
Technology	Analog technology records waveforms as they are	Sample analog waveforms into a limited set of numbers and records them

Deterioration during transmission	Subjected to deterioration by noise during transmission and write/read cycle	Can be noise-immune without deterioration during transmission and write/read cycle
Response to Noise	More likely to get affected reducing accuracy	Less affected since noise response are analog in nature
Flexibility	Analog hardware is not flexible	Digital hardware is flexible in implementation
Bandwidth	Analog signal processing can be done in real time and consumes less bandwidth	There is no guarantee that digital signal processing can be done in real time and consumes more bandwidth to carry out the same information.
Memory	Stored in the form of wave signal	Stored in the form of binary bit
Power	Analog instrument draws large power	Digital instrument draws little power
Cost	Low cost and portable	Cost is higher, but steadily reducing
Impedance	Low	High order of 100 megaohm
Errors	Analog instruments usually have a scale which is cramped at lower end and give considerable observational errors	Digital instruments are free from observational errors like parallax and approximation errors.
Data transmission capacity	Much lower than digital	High, using the same spectrum as analog

4. Advantages and Disadvantages of DTH

DTH comes with advantages and disadvantages. They are listed as follows:

Advantages

- Each satellite covers a large area using Line of sight transmission due to their height, unlike terrestrial transmission which needs to have multiple transmitters for covering the same area.

- The transmission cost remains the same, even for a very large area. No overhead of setting up cables as each end user requires one small dish.
- Its signal is digitally encoded and uses digital compression techniques to utilize the spectrum much more efficiently. This leads to a much higher number of channels than analog terrestrial and cable broadcasts. This also makes HD TV possible.

- An inexpensive solution to broadcast TV signals in mountainous regions, where traditional broadcast may not be effective due to the terrain blocking the signals or scattering them. Laying cable infrastructure in such hilly areas is also difficult and costly.

Disadvantages

- There may be disruption in services due to bad weather, as clouds can attenuate and scatter satellite signals. The small DTH dishes are also not able to receive a sufficiently strong signal. Cable systems do not face these kinds of disruptions, as they use centralized large dishes with wired transmission to houses. Also, terrestrial broadcasts would not be disrupted by clouds/ bad weather.
- Installation of even smaller dishes might be problematic in crowded localities, flats etc.

5. Conclusion

DTH satellite broadcasting has evolved a lot since it's early days. From using large motorized dishes to small fixed household dishes, DTH technology has become much more practical and efficient. Today, hundreds of DTH satellites beam down TV signals to millions of subscribers. Behind the scenes, advances in digital communications, compression, satellite and antenna technology and encryption have made DTH possible at this scale. Due to its ease of setup, high quality service and numerous other advantages, it is a very popular way to access TV for many people all over the world, especially in remote areas.

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