

Researched by: Vladimir Mitic 9717407

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Project title:

Open Cable Architecture

- **What is Open Cable?**

Open Cable is set of functional requirements and interface specifications to build a digital cable set-top. Such requirements must meet rapid development of digital technology that is merging digital television with personal computers and the Internet.

Open Cable initiative started in 1997 with the creation of an Advanced Set-Top Taskforce. The initial 23 respondents have grown to more than 3000 vendors that are involved in the Open Cable specification process.

- **Digital Television and compression**

The invention of the television is 60 years old. It had been developed using vacuum tubes (“valves”), then replaced by TTL (transistor-transistor logic) and later with CMOS (Complementary metal-oxide semiconductor). Relating to the Moore’s Law¹ that states that the number of transistors on a chip was doubling every 18 months with no end in sight until perhaps 2030.

This very large scale of integration (VLSI) encourages the designers to put many functions on a single chip. Also, because it is very tricky to mix analog signal with digital, even relatively complicated digital circuits are replacing even trivial analog functions, such as audio mixing. The first industry (in the 1970’s) to radically employ digital signal processing is the audio industry. The compact disc was introduced in the 1980’s, and it is nearly impossible to purchase cassette tapes and vinyl records today. Still, today’s compact disc stores music in a raw format without any compression. Using digital compression (mp3 format) it is possible to increase the capacity (minutes of music per disc) of the compact disc by a factor of 10.

The same way video digital compression (mpeg-2 format) allows increase in number of channels offerings through a regular coaxial cable by a factor of 10. The retina of human eye perceives more detail with rod cells, which are sensitive to intensity of light only – the luminance – and perceives less detail with cone cells, which are sensitive to the color of light – the chrominance. Mpeg-2 “chroma sampling” takes advantage of that and the luminance information is sampled at 480x720 resolution while chrominance information is sampled at 240x360 resolution, which is called 4:2 sampling.

- **Analog Set-top Converters**

Analog Set-top converters support an electronic program guide (EPG) and impulse pay-per-view (IPPV). They are bad for any kind of interactive signaling. Common degradation in picture occurs due to analog scrambling/descrambling. Also analog scrambling is far too easy to defeat. In 1999, the cable industry lost more than \$5 billion to unauthorized access of premium cable signals².

¹ More about Moore’s Law: <http://www.intel.com/pressroom/kits/bios/moore.htm>

² Open Cable Architecture, Cisco Press, ISBN: 1-578790-135-X

- **Digital Set-top Converters**

Premium digital channels are secured using digital cryptographic techniques that are much harder to break than analog scrambling.

- Channel expansion – since digital compression makes bigger bandwidth.
- On-demand services – allocates a dedicated digital stream/channel to each active user.
- Quality – bigger bandwidth and no snowy or ghosted images.
- Security – cryptography can be employed.
- Flexibility – stream can be decoded to fit the requested resolution.
- Data transmission – Can send video, audio or just data with equal ease.

- **Hybrid Fiber Coax (HFC) Upgrade**

FCC (Federal Communications Commission) mandates that in 2006 all broadcast will be fully digital. It is not necessary to upgrade the cable system to carry digital television services. However HFC can carry both analog and digital services, improve reliability and performance. Also, it upgrades effectively segments of the cable system into large number of parallel distribution networks. It is supported by a three-level topology of headend, distribution hubs and fiber nodes.

Headend is a satellite receiver site, and it is the origin of content concerning its local network. It is also connected in the ring network with other headends.

Distribution hub (typically 20,000 homes passed) supplies a large number of fiber nodes and it is connected with the headend in a ring topology.

Fiber nodes (usually 500 homes passed) are usually connected in a star topology to reduce cost.

Since all these components are connected as networks, there are no amplifiers and no data loss due to the noise. The only part of the communication channel that is prone to the noise is the one that connect the fiber node to the set-tops in each home. Each fiber node is connected with the old fashioned coaxial cable at each home. In order to make two-way connections, the signal is amplified in both forward and reverse directions. This is achieved by partitioning frequency spectrum or also called *diplex filter*. Range of 54-870MHz is used for forward direction while 5-40MHz for reverse direction. Digital signal is converted into Radio Frequency (RF) and sent through coaxial cable. Therefore, if any of the homes still have old-fashioned analog set-top it will still work. This way the system does not have compatibility issue. Also since *Fiber node* passes data to usually 500 homes – no more, there is no noise involved.

- **Services**

New services will use digital television - blending entertainment with communications, based on high-speed technologies that increase bandwidth of cable systems. Some services are already being tested as:

- *Video-on-demand* (VOD) (also called “Personal television”³)

Today in Austin, Texas 130,000 people enjoy VOD system in their homes. It has demonstrated that HFC upgrade provides a massive increase in the bandwidth available to each customer. It is economically proven that this works since digital set-top has been cost reduced and VOD has significantly higher buy rates than impulse pay-per-view service. Users have total comfort of pausing, fast-forwarding, replaying the movie, selecting shows and scheduling the program to fit their individual needs.

³ More about VOD: <http://www.schange.com>

- Linked advertising

Linked advertising gives customers the ability to customize how they receive advertisements over television. For example they can skip them altogether (perhaps for a fee) or specify areas of interest for which they would like to see ads.

- Linked merchandising

This model lets customers buy products that are shown in a program, provides discounts for services with the purchase of one of digital services, like a discount pizza with a movie rental/purchase.

- Linked communications

Example of this kind of service would be linking a chat session to a live television broadcast allowing the customer to play game show and so on..

All services are divided into two sections. Interactive and On-demand services:

- **Interactive Services**

Interactive services provide a wide range of services to the customer as a two-way communication medium. Some of them are:

- Home Shopping

- Home banking

- Email

- Web access

- Electronic games

- Stock tickers

Interactive services tend to use multiple sessions for short bursts of communication, so they require connectionless signaling mechanism, such provided by IP networking.

- **On-Demand Services**

On-demand services also provide interactive services. However, are different in the sense that they provide a dedicated video and audio stream to the customer via the cable system in addition to interactive service. Some of them are:

- Movies-on demand

- Music-on demand

- Post-broadcast on demand

- Library access

- Video mail

On-demand services require a continuous stream of data that is best provided by a connection-oriented network, such as that provided by ATM.

- **Issues**

In the trend line toward the free Internet, service providers will be more inclined to seek revenue sources, such as e-commerce and advertising, outside of subscription fees. Nobody knows whether these or other model will unlock new revenue streams. Anyway all these models are enabled by the digital television. Software based approach can be flexible enough to support these and many other services. So applications can be developed independently of the hardware model, allowing many incremental opportunities.

Copy protection is an issue. "Modified Diffie-Hellman key exchange" is the method that uses generation of random numbers to generate a shared secret key. This key is refreshed periodically to reduce vulnerability to brute-force key search attacks. The same method is used for payload encryption. This makes it difficult for the customer to make illegal copies of the payload. However, a serious pirate could modify or even manufacture fraudulent hosts, which are designed to bypass copy protection system.

More issues and their solutions are covered in the open cable specification documents⁴.

⁴<http://www.opencable.com>