DOCSIS SET-TOP GATEWAY (DSG): NEXT GENERATION DIGITAL VIDEO OUT-OF-BAND TRANSPORT

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Abstract

The cable industry has found a perfect weapon to create a sustainable competitive advantage against satellite operators and converge services over a common, standards-based network. Offering value-added services such as on-demand video and gaming creates much needed differentiation that satellite technology cannot offer. Due to the success of its high-speed Internet business, cable operators have built the largest IP networks ever assembled using DOCSIS technology. The industry is looking to extend the power of their DOCSIS data networks to the digital video part of their business. The current video network is based on a costly, proprietary architecture that does not scale to efficiently or cost-effectively support high-bandwidth, interactive services. It is essential that cable operators evolve their digital video networks to a high-bandwidth converged architecture that leverages prior investments in HFC cable plants and enables the video side of operations to benefit from open standards.

DOCSIS Set-Top Gateway (DSG) technology promises a major step towards a converged data, voice, video network. DSG enables standardization of set-top technology and offers the potential to reduce set-top box (STB) costs by half. While Korea leads in the adoption of this technology, major U.S. MSOs are examining the technology and making plans to deploy DSG later this year.

This paper covers constraints of the traditional digital video network transport architecture and discusses benefits to migrate to a next generation DSG-based network.

CURRENT CABLE NETWORK

Cable operators today maintain at least two distinct networks: one for standards-based DOCSIS data IP services and a separate, proprietary digital video network.

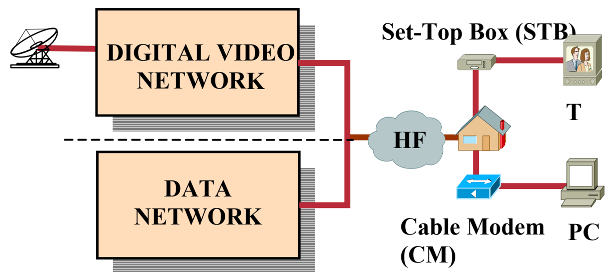

Figure1: Current Cable Network

Given investments made on the video network side for U.S cable operators, the migration to a standards-based, next generation architecture is expected to occur in phases. As shown in Figure 2, the three main aspects of the video architecture are the video services/application plane at the top that comprise the video application level supporting the infrastructure; i.e., application servers, broadcast video, VoD servers, conditional access servers (CAS), and billing. The middle level comprises the control plane that involves sending control messages such as entitlements, STB provisioning, control session and resource management, system information and program guide information to the STB. These control messages are UDP/IP encapsulated. The lowest level in the architecture is the network transport plane that carries video traffic and control messaging. The network architecture consists of separate transport for the video transport and messaging plane.

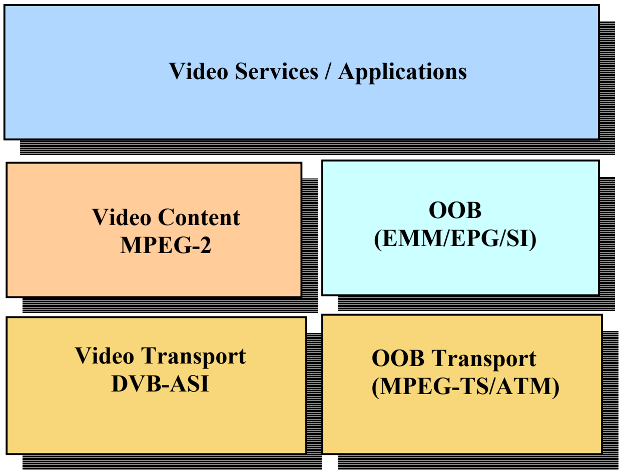

Figure 2: Digital Video Network Architecture

The video transport backbone is migrating from a point-to-point DVS-ASI network that has limited scalability to a switched Gigabit Ethernet backbone to a routed IP network from video servers up to the edge modulator. A future phase of video transport involves migrating to a converged data/video infrastructure. The control plane represents the next immediate logical point to migrate to a converged network. The legacy video messaging control transport is referred to as out-of-band (OOB) since this class of messaging is transported outside of the main video transport.

Legacy Video Network Architecture

At the core of the traditional digital video architecture is proprietary technology between the STB and the headend network architecture. Due to this proprietary technology, introducing innovations on the network side and in the STB have been slow. The network architecture can not be changed without changing the STB technology and vice versa. That has locked cable operators into older video architectures, hampered the introduction of high-bandwidth, interactive services and kept equipment and maintenance costs high.

Out-Of-Band (OOB) Transport

Traditional STB technology relies on the use of a dedicated channel to transmit control messaging from the headend to each STB. Conditional access (CA), system information (SI), electronic program guide (EPG), emergency alert system (EAS) and other STB command and control messages are sent via a downstream RF channel that is separate from the channels actually being watched. A low-bandwidth upstream reverse channel is used for interactive messaging.

The OOB carriers require separate, proprietary headend equipment such as out-of-band modulators and return path demodulators. The OOB channel is typically located in a reserved portion of the downstream HFC spectrum at 75.25 MHz and uses quaternary-phase-shift-keying (QPSK) modulation with 1.8 MHz of RF bandwidth. An OOB gateway in the headend system receives the content for the OOB channel over an IP/Ethernet connection from an application server, terminates the IP/Ethernet connection, and converts the content to ATM or MPEG-TS frames before passing the content down the OOB channel to the STB.

Most of the signaling messages from the application server are fed through another software program called a carousel and broadcasted on the OOB channel. The carousel periodically sends out the messages from each application in sequence. The return path in such a system is typically operated through a polling mechanism over the OOB.

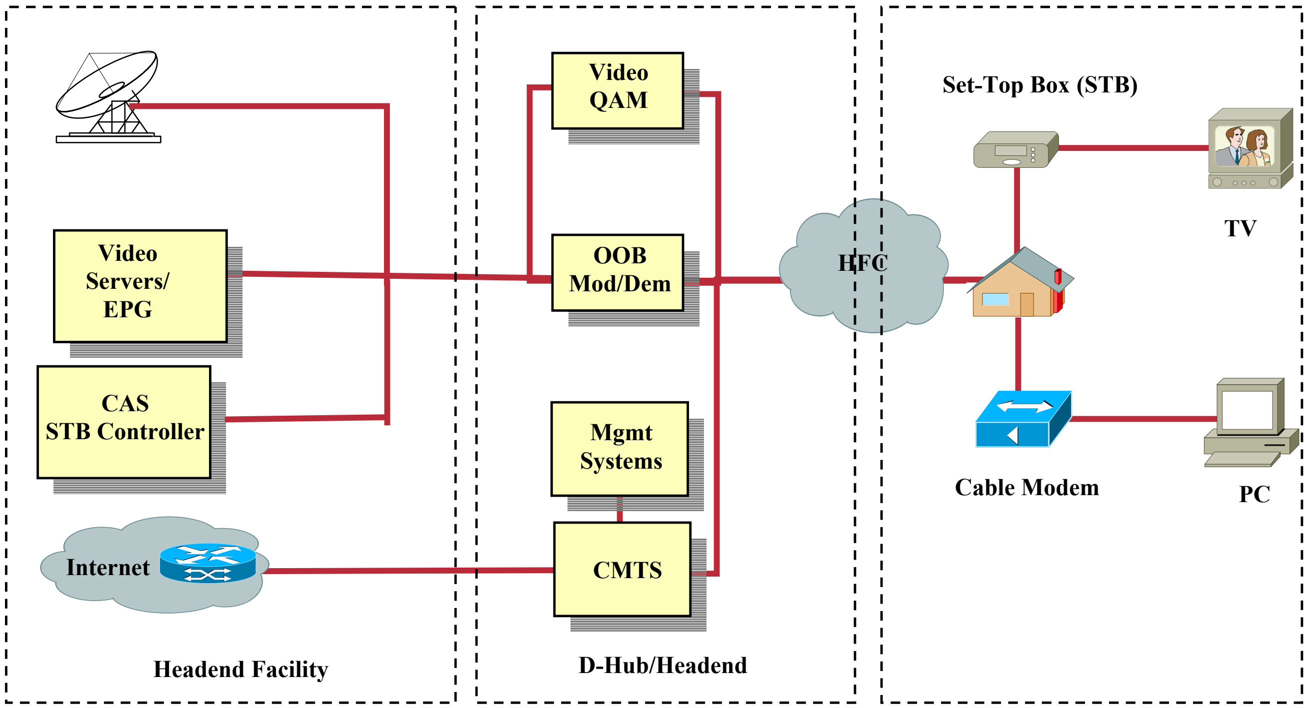

Figure 3: Legacy Digital Video Network Architecture

The upstream is a low-bandwidth transport used to poll STBs for pay-per-view subscription information. The combination of the OOB downstream and the upstream return path resembles a first generation DOCSIS system.

The OOB data is essentially broadcasted to all STBs in the legacy network path with the application level filtering the data that belongs to the STB. All data, regardless if it is Broadcast, Multicast or Unicast in nature, is broadcasted. This results in inefficient use of network bandwidth.

NEXT GENERATION VIDEO ARCHITECTURE

As part of the CableLabs® OpenCable™ initiative, a number of vendors and cable operators have been working to specify an open architecture for cable headend equipment, application servers, and digital cable STBs. OpenCable, the standards organization laying the groundwork for traditional digital TV and new interactive video services, has developed the *DOCSIS Set-Top Gateway (DSG) Interface Specification*. This specification defines interface requirements for transport of out-of-band (OOB) messaging between a set-top network controller, application servers, and customer premises equipment such as residential gateways and STBs.

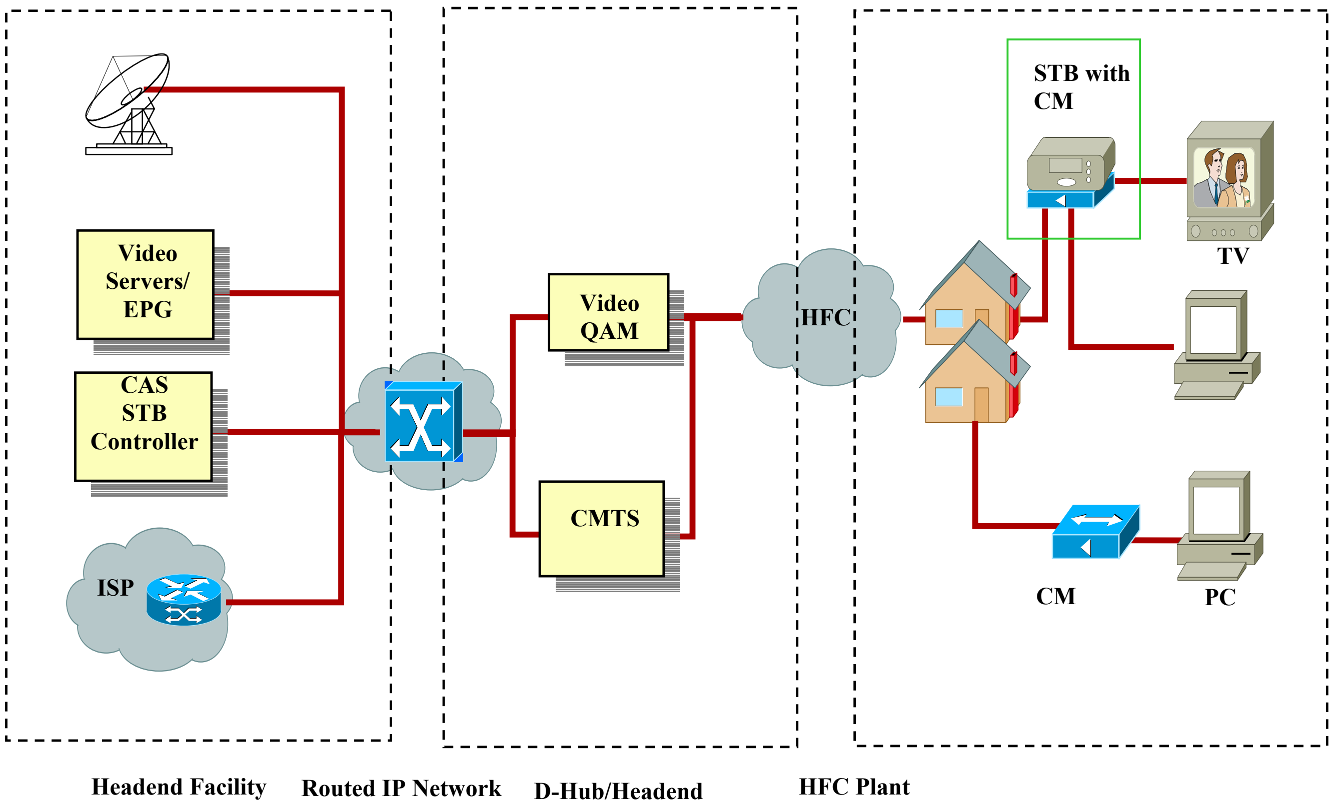

Figure 4: Next Generation Digital Video Network Architecture

The DSG specification moves away from proprietary OOB transport to widespread, IP-based technology, while at the same time, preserving the current control plane messaging. The control information is carried on an "always-on"channel that is separate from the video delivery channel. DSG is typically implemented on a CMTS which is the edge device facing the HFC network.

DSG Benefits

The first key benefit that DSG offers is that it provides a robust transport path over DOCSIS. DSG delivers OOB messaging in one-way plants. DSG provides downstream transport for OOB even in the presence of reverse channel impairments. In two-way plants, DSG continues to deliver OOB messaging even in case of reverse channel impairments, which otherwise would not be possible with plain DOCSIS-based STBs. The second key benefit that DSG offers is that it allows cable operators to leverage DOCSIS networks and efficiently support new STB implementations. DSG consolidates control traffic from the video network onto the DOCSIS network, thereby reducing operational costs. OOB traffic can be sent using DSG over a dedicated downstream RF channel or piggy-backed on an existing channel used for high speed data. Analysis shows that consolidating OOB traffic with high speed data yields maximum cost savings.

The third key benefit that DSG offers is higher downstream and upstream bandwidth that accelerates rollout of new interactive video services. This in turn leads to higher cable operator revenues. A DSG-interoperable STB with an embedded modem makes use of the higher DOCSIS bandwidth to transport interactive on-demand traffic such as VoD requests, and gaming.

Delivering IP Multicast or Unicast OOB to Set-Top Boxes Efficiently

DSG allows integration of OOB traffic that is sent via IP Multicast or IP Unicast from application servers on the network side to be delivered on a one-way HFC downstream to STBs. Although a STB may have an IP address, DSG acts as a proxy device to facilitate delivery of IP/UDP OOB traffic to the STB. In case of Multicast traffic, DSG maps the incoming traffic on a particular Multicast Class D address to a DSG tunnel that is characterized by a well-known MAC address. This MAC address is unique per CAS vendor and is either embedded on the STB SmartCard or OpenCable Point-of-Deployment (POD) module, enabling the STB to listen on the right tunnel. Alternatively, MAC addresses are dynamically passed on to the STB by the DSG client as defined in the DSG advanced mode specification. The DSG advanced mode specification is part of the next revision of the CableLabs DSG specification. Most of the OOB data, being Multicast in nature, requires DSG to support Multicast on the network interface and efficiently delivers data to a specific set of STBs. Since STBs are required to operate in a one-way mode, STBs can not make IGMP JOIN requests. DSG acts as a proxy Multicast host and creates a static IGMP JOIN of cable interfaces. To ensure only authorized application servers are allowed to send OOB to the STBs, Source Specific Multicast can be used.

SUMMARY

DSG not only offers cable operators cost savings from consolidation of OOB video and HSD networks, but it opens up a number of opportunities to generate additional revenue streams from rollout of high bandwidth-intensive services. DSG provides digital video networks a gateway to sustained innovations of DOCSIS, including advanced capabilities in spectrum monitoring, analysis, and network management.

DOCSIS is the standard of compliance and fundamental approach adopted worldwide to enable IP data, voice, and video services on an HFC network. OpenCable and DSG pave the way for similar advancements in video. Using DSG, cable operators can overlay operation of legacy STB technology and migrate to open-standards-based STBs. Cable operators can leverage their HFC infrastructure and DOCSIS CMTSs to consolidate cable modem and STB data traffic on a shared DOCSIS channel.

Korea is spearheading deployment of DSG. One of the main reasons Korea is leading in adoption of DSG is due to the greenfield cable video market and absence of legacy systems. The Korea Digital Cable Forum, along with TTA—the regulatory organization in Korea, announced DSG adoption last year. Broadband Systems Inc, a subsidiary of Powercomm Korea is the first digital video provider to deploy DSG. Using DSG, BSI hopes to lead in deploying high bandwidth interactive services like video-on-demand and popular video gaming services. U.S. MSOs are not far behind. They are defining solutions for their legacy networks and plan to evaluate and deploy the technology later this year.