# HYBRID IP-QAM VIDEO SOLUTIONS

Christopher Poli, P.E., Richard Moore, William Weeks
Motorola Connected Home Solutions

*Abstract*

*A Hybrid IP-QAM System Architecture is one of the most effective architectures available today in expanding plant capacity – allowing operators to offer an expanded and wide spectrum of high definition, international and niche programming. The architecture is capable of fully supporting Broadcast, Unicast or Narrowcast services (i.e., VOD) and Switched Digital Video; multiple video encoding formats (e.g., MPEG-2, MPEG-4) and can support a transition to an all IP STB solution. While a complete IP network build-out will likely take years and millions of investment dollars to complete; a hybrid system provides a bridging architecture without stranding existing set-top assets. This paper provides an overview of this architecture including a comparison of the bandwidth delivery provided in hybrid architectures to that of other architectures.*

## INTRODUCTION

The competitive landscape is changing and becoming more challenging. Satellite delivered TV has publicly announced plans to launch 150 HD channels (source: DirecTV website) – nearly ten times the typical HD offering of most cable MSO's. It would take 75 QAM streams of cable plant capacity to carry that many HD services in MPEG-2 format. Competitors are deploying highly competitive video services in many major markets with plans to offer richer content and more bandwidth than is possible in an HFC plant. VOD capacity requirements continue to grow – pushing nodes deeper into the cable plant. Symmetrical applications such as VOIP and internet applications continue to increase pressure on high speed data rates.

Over the past couple years, at least one major successful deployment of a national hybrid QAM IP architecture has already occurred (and continues to expand). Municipal entities are in the planning stages or have already begun overbuilding as well – some are looking at a pure IPTV play and others at hybrid architectures that provide both broadband IP and QAM delivery capabilities.

There are options to increase the effective plant bandwidth capacity beyond splitting nodes to the point of fiber exhaust. Moving to 1 GHz for data services may also provide some relief (video still up to 860 MHz). Going all digital – and recapturing analog spectrum. Switched Digital Video is an emerging technology as another means to reclaim channel bandwidth – and combined with DOCSIS 3.0, could provide significant relief to forward bandwidth demand – both from a video services standpoint as well as data services. All of these activities certainly help a great deal in the forward path, but they neither address the longer term need for significantly more bandwidth nor the need for significant additional symmetrical bandwidth.

This paper will cover an End to End Network and System Architecture culminating in a PON based delivery to the home with hybrid IP and QAM capable set-tops. A hybrid IP QAM set-top has the capability to receive services both on an IP interface and through the more traditional QAM tuner. The set-top applications determine the video source to be displayed or recorded. The IP interface can use either a traditional ethernet interface or a home network coax-based interface such as Multimedia over Cable Architecture (MoCA) or HomePNA. A home network based architecture such as MoCA can provide 70-100 Mb/s IP interface over an RF channel that runs above 860 MHz. A properly deployed, Hybrid architecture offers strategic advantages to the service provider.

The paper will also cover benefits of integrating Video on Demand or other singlecast services onto the IP data path, and briefly describe the use of multicast on the IP pipe to deliver carousel data, tunnel singlecast data, or deliver IP video services. The paper will finally cover how an IP capable architecture can enable seamlessness in communications to a multitude of home and mobile devices – a two way IP pipe to stay connected to the world.

## BANDWIDTH NEEDS

How much bandwidth is enough? With the proliferation of HD content and multiple HD TV sets in a single home, bandwidth required to the home in either a traditional HFC or Switched Digital delivery will drive the need for architectures that reach beyond simply pushing QAM nodes further and further outward toward the edge. As the price of HDTV sets continues to fall, and the obvious quality difference between HDTV and Standard Definition TV continues to rise within the subscriber base, the need to deliver richer content – certainly beyond the typical 10 to 20 HD services offered in an HFC plant - will rise significantly in the near future. Add to that the ever increasing demand for data services bandwidth and it may become apparent that subscriber demand will exceed today's HFC QAM channel plant capacities. The cable provider who is prepared to deliver the bandwidth to enable these services and more will have a significant competitive advantage over the operator who cannot.

In today's MPEG-2 environment, delivering 100 HD streams and their equivalent SD streams will consume on average 60 QAMs. That is nearly half of the QAM channels available on an 860 MHz HFC plant. Take away analog channels and those dedicated to data and there is very little bandwidth left to deliver compelling services such as VOD that are capable of significantly reducing subscriber churn. While data services may likely be moved above the 860 MHz channel frequency to extend available bandwidth, it still requires pushing the nodes further and further out into the plant to provide the needed bandwidth to deliver all the services desired. As nodes are split, fiber exhaust may become a serious consideration in the long term.

How much bandwidth is required in building out a pure IP network that has the ability to deliver enough bandwidth to each home to provide satisfactory service? Even with the promised bandwidth advantages of MPEG-4, high definition services will consume 8 Mbps/service. If we assume a peak requirement of simultaneously delivering two HD services, an SD service and 6 Mbps best effort data service, then the peak BW per home is approximately 26 Mbps to a single home. Although some of the bandwidth is delivered to multiple homes in an IP Switched Digital Video deployment, that network will need to be managed – meaning that decisions to allow new video sessions to traverse a particular path may be dependent on current bandwidth consumption on that path. Depending on specific market assumptions, the 26 Mbps/home number may be adjusted upward or downward. It certainly would be no less than 20 Mbps/home and an argument might be made for as much as 40 Mbps/home or more. While this number may seem absurdly high today, how long ago did 750 Kbps DSL, 1.5 Mbps DSL or 6 Mbps Cable Modem rate seem absurdly high when phone line data connections were only capable of delivering 56kbps? Data customers moved very quickly from slower data service providers to high speed cable modems. The future may hold another migration to competing services that offer more or business-necessary erosion to service margins to keep the current customer base.

Today's HFC services compete for available bandwidth. In a typical HFC architecture, QAM channels are allocated across multiple service types. As bandwidth demands increase, HFC architecture may move toward Switched Digital Video where a number of QAM channels are allocated to switched broadcast (essentially multicast), singlecast (i.e., VOD) or data services. Depending on the allocation and number of subscribers served per node, these nodes will push deeper and deeper into the network requiring more and more fiber to provide the more effective bandwidth per subscriber to remain competitive.

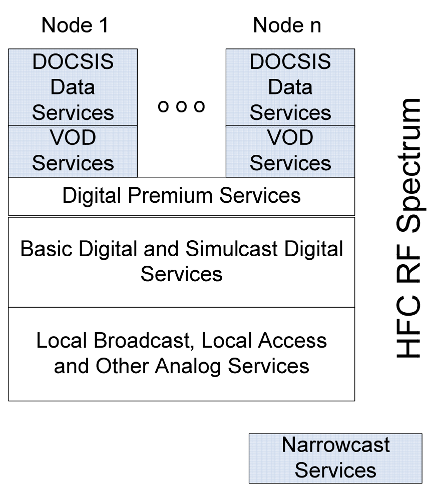


Figure 1: Typical HFC Services

This paper is not aimed at converting from a typical HFC architecture to PON architecture as conversion may have an insurmountably high network infrastructure, headend and customer premise cost and does not adequately leverage the enormous investment in the current QAM plant. Rather, the description above points out what is already available on the QAM side of the hybrid architecture – including the application management layer. This HFC foundation can be expanded by adding in the PON architecture with only minor changes to the existing video infrastructure.

## HYBRID QAM-IP ARCHITECTURE

A QAM-IP architecture enables existing, previously integrated QAM based applications and augments that plant capacity with an IP infrastructure that can grow as demand for bandwidth grows. Deployed applications can easily migrate to utilize the IP back channel as opposed to traditional thin-pipe RF return.

Hybrid architectures provide significantly more forward broadcast and narrowcast capacity than non-hybrid architectures. At the same time, density of homes per GigE served can be increased since the majority of forward video broadcast load can be delivered on the QAM portion of the plant. A hybrid QAM IP architecture using a typical GPON delivery can offer a full 860 MHz QAM plant (or 1 GHz if data rides above 860 MHz). In addition, the OLT acts as a multicasting engine and switch that allows 32 users to share up 2.4 Gbps IP downstream and 1.2 Gbps IP upstream.

A typical Hybrid IP-QAM PON Architecture utilizes a dedicated wavelength for the traditional 860 MHz cable plant services and separate dedicated wavelengths for the IP connection upstream and downstream. These can be carried on the same fiber or on different fibers to a node accumulation point or to the side of a home. Figure 2 illustrates a system deployment to the side of a home.

The Headend or Supernode has typical cable headend functions including derivation of broadcast video services, VOD (may also be delivered directly on IP path), IPPV services, and out of band messaging (may include CAS, EPG, and set-top related configuration services). Services are received, processed (may include ad insertion), encrypted (as required), RF combined and transmitted optically on 1550 nm wavelength. Data services including

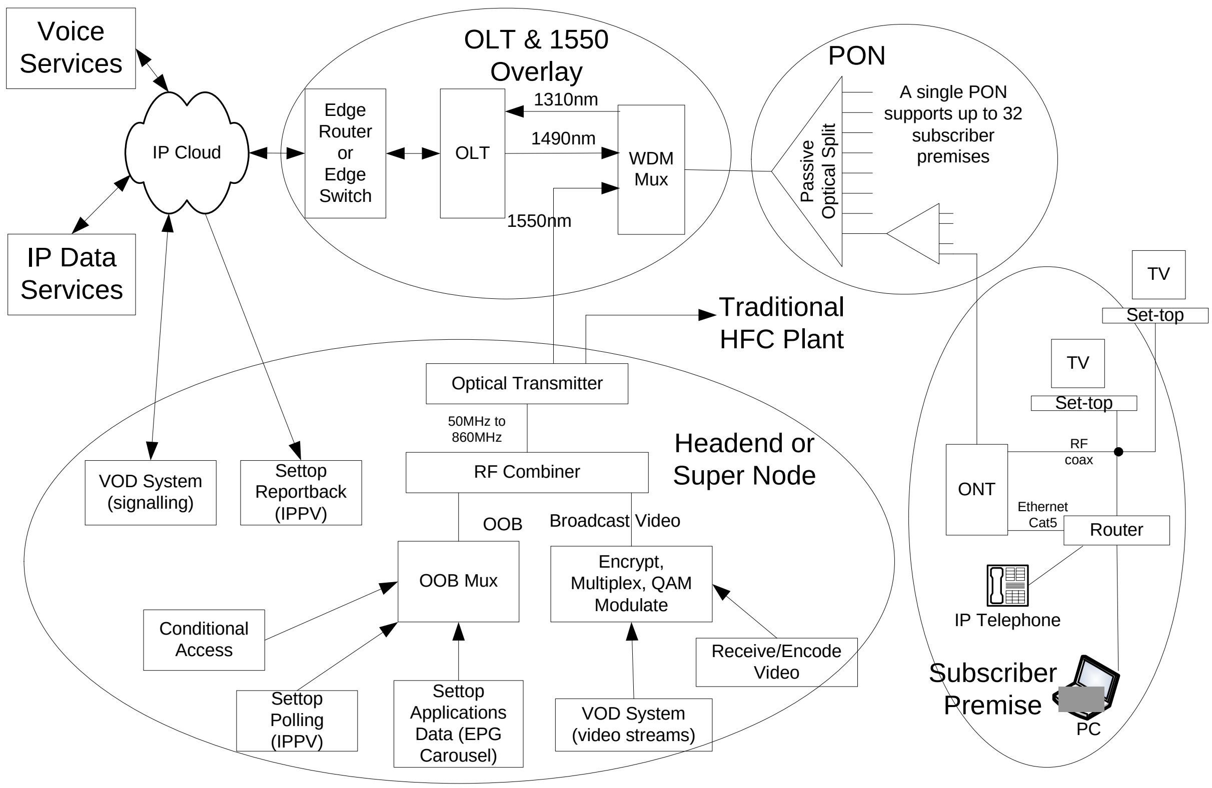


**Figure 2: Functional Hybrid PON Network – IP Return Channel**

VOIP and optionally video services such as VOD can be delivered on a separate IP path, transmitted optically on 1490 nm wavelength. 1550 and 1490 wavelengths are wave division multiplexed onto the PON at the output of the OLT. The return path from the ONT to the OLT is IP on 1310 nm and no RF demodulators are required to receive upstream transmission from the set-top. In addition, application communications downstream may also traverse the IP path and an OOB communication channel downstream (such as utilized with some RF return networks) is not required. Specialized headend equipment to enable communication from application server in headend to application client on the Q-IP set-top is eliminated/not required. All connectivity can be provided through an IP network connected through an upstream edge switch/router to the OLT.

In figure 3, the OOB multiplex, set-top application data and VOD system are moved completely over to the IP data path. In addition, new services such as streaming video and even switched video can be provided across the IP path. Lastly, all return channel functions are also moved to the IP path. Carousel data is easily handled with the multicast capability of GPON. Specific requirements for IP multicast data carousel would likely be application dependent.

Application signaling (such as required for VOD) and application service delivery is typically singlecast to the client. By providing for both QAM and IP paths, bandwidth utilization – particularly on the forward path – can be optimized, and flexibility in the manner in which services are delivered is maintained.

The subscriber premise as shown in both figures 2 and 3 assume a home IP network over coax such as Multimedia over Cable Architecture (MoCA) or HomePNA which provides return path channel and

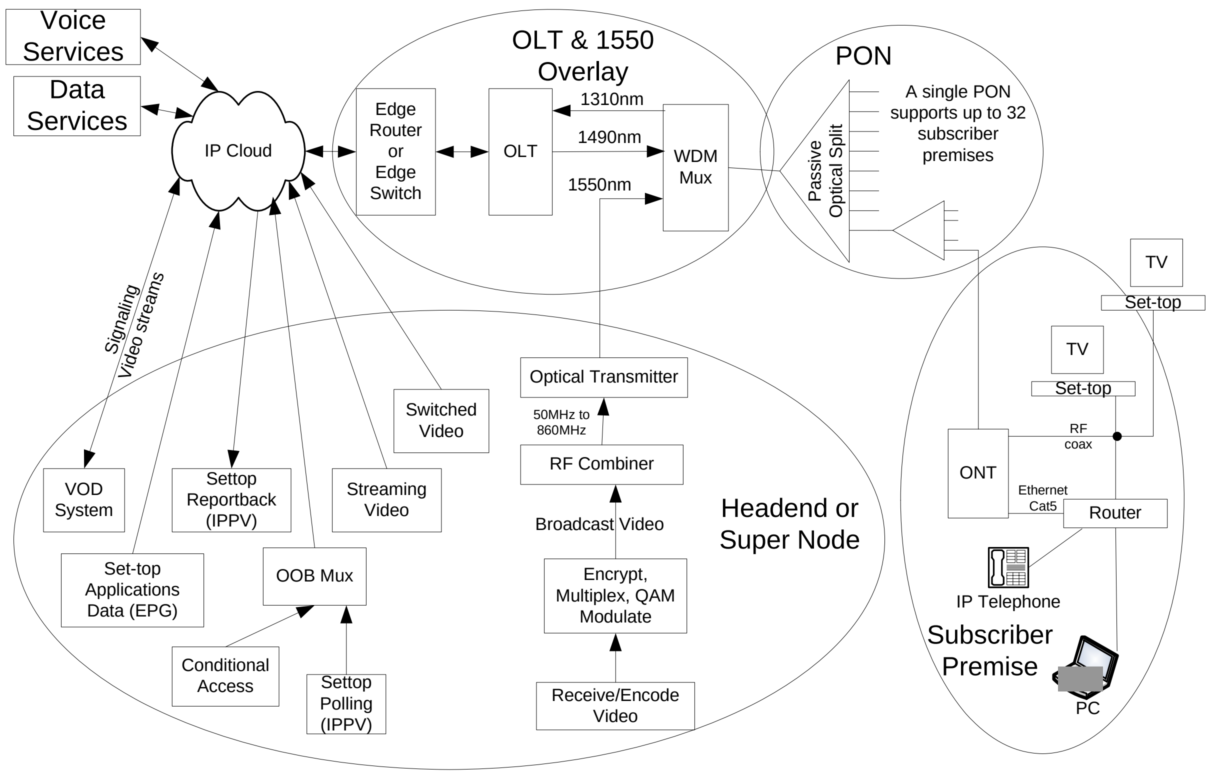


**Figure 3: Functional Hybrid PON Network – IP Services**

enables advanced features like whole home network or multi-room DVR. MR-DVR will allow video to be selected and streamed from a DVR set- top to a non-DVR set-top on the same home network. Set-tops may be provisioned behind a home router or directly from the network / system. Ideally, set-tops sit behind a home router and are provisioned locally on the home LAN. DHCP and DNS functions are used for IP provisioning and application client-server connection. Standard IP protocols govern both provisioning and communications.

Specific deployment requirements may vary based on existing operator infrastructure and longer term desires. Considerations may include existing network and equipment deployments, fiber availability, provisioning requirements, and the like. Benefits of integrating Video on Demand or other singlecast services onto the IP data path, and the use of multicast on the IP path to deliver data or video services provides more bandwidth on the QAM side of the hybrid architecture which will allow high bandwidth HD broadcast services to be delivered without consuming all important bandwidth for future applications on the IP side. Lastly, an IP home network can more readily enable seamlessness in communications using an IP network to a multitude of home and mobile devices – a two way IP pipe to stay connected to the world.

## PROS AND CONS

Reasons for deploying PON based architecture include substantially enhancing bandwidth to the home easing future bandwidth constraints, using it in targeted areas where competitors are focusing, and lower maintenance costs than an active and largely metallic network. FTTP certainly must be considered for greenfield deployments. Challenges include costly rebuilds that may not be popular in the near term to stockholders and potentially stranding some deployed investment assets as new technology is deployed.

## VISION FOR THE FUTURE

An IP enabled cable plant allows for more diverse service offerings as well as provides a framework for the future. Transcoding to formats such as MPEG-4 in the headend will allow for more services in less bandwidth. It is expected that MPEG-4 content would be delivered over IP simply because it is assumed the receiving consumer device will have an IP interface.

Transcoding content in the HE may also enable delivery over other mediums such as wireless/WiFi/cellular/DVB-H networks. In such a seamless network, IP video delivery requires the creation of SPTS, individually transcoded and encrypted and either stored on a headend server or streamed directly to the mobile user.

In a seamless mobility solution, operators collectively deliver a continuous experience of content. Using a network management protocol such as IMS, switching Cable, Wireline and Wireless sessions occurs at the session layer. The transport layer – meaning any transport layer, including a network managed IP or QAM broadcast service – provides transport services only. Applications become transport indifferent. Subscriber access points may be Cable, Data/IP (FTTP), Cellular, WiFi, or WiMax, but are driven by the subscriber and associated applications. In an ethernet centric world, a bandwidth rich IP infrastructure is absolutely necessary to stay competitive and the additional QAM transport layer provides downstream capacity that offloads the IP infrastructure substantially.

Bottom line - Hybrid architectures allow the operator to be ready to fully enable the flexible Connected Home.