



# Bridging the Light to the MDU

By Van Nguyen, Senior System Architect, Pacific Broadband Networks (PBN)

**While large-scale deployment of RFoG is currently still challenging, the use of RFoG technology in an MDU application has the momentum, is cost efficient and is the first economical step towards an all-fibre network.**



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Van Nguyen is Senior System Architect at PBN and based in Melbourne, Australia. PBN is an experienced global supplier of optical broadband products and technology solutions for HFC, RFoG, FttX and EMS/OSS applications. PBN is well known globally for its innovation and expertise, offering advanced fibre optic products and solutions for applications demanding high bandwidth. Today, PBN products are being installed to deliver comprehensive broadband access solutions to over 30 million subscribers, served by hundreds of head-end facilities worldwide.

In his role, Van is responsible for strategically designing and implementing systems and architectures that support core organisational

functions. Previously, Van held the position of R&D Manager at PBN, with many years of experience in product research and development. Van's career has been centralised around R&D for HFC and FttX solutions. Van's involvement ranges from high level system design to low level electronics and software design. Before joining PBN, Van was working at Vision System on network management software.

Van was awarded a scholarship for his Bachelor of Engineering and completed his Master of Digital Communications at Monash University, Australia. Van has an active interest in IEEE and SCTE groups, and particularly in PON and RFoG standards.

Whilst FttH (Fibre to the Home), targeting single-family units, is gaining more momentum around the globe, Fibre to the MDU (Multi-Dwelling Unit) represents a significant slice of market share. FttM (Fibre to the MDU), especially in densely populated cities, offers a rewarding opportunity for operators to increase ARPU (Average Revenue per User) by providing higher bandwidth and added services. FttM requires significantly less investment compared to FttH, whilst the service penetration rate is higher.

However, the lucrative opportunity of rolling out FttM does not come without challenges. Success has to be based on choosing the right technology and architecture to deliver a reliable system in a cost effective way.

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## PON + EoC

The PON+EoC architecture, as the name implies, is a hybrid of PON (Passive Optical Network) and EoC (Ethernet over Coax) technology. The PON is responsible for delivering traffic from the head-end to the MDU location, whereas EoC handles the traffic within the building's existing coaxial plant.

As can be seen in Figure 1, data and video CATV traffic are multiplexed into a SM (Single Mode) fibre. The distribution network is passive, with only optical splitters in the field. The MAU™ (MDU Access Unit) includes an ONU (Optical Network Unit) that delivers Fast or Gigabit Ethernet data. The data is then forwarded to an EoC-Master or Network Controller, which further distributes data to the in-building coax system. An EoC CPE (Customer Premises Equipment), installed in each apartment, provides both Ethernet data and CATV RF output ports.

Although each OLT (Optical Line Termination) can support up to 64 ONUs, typical MDU deployments range from 4 to 16 splits, depending on the SLA (Service Level Agreement) and the take-up rate. Within a building, the EoC network controller can handle around 31 EoC CPEs. Thus, for example, with an 8-way split, almost 250 customers can be served using a single PON. CATV is implemented as an overlay on a 1550nm wavelength. The MAU incorporates a CATV optical receiver with one or more high-RF outputs (over 100dBμV) for in-building RF distribution.

## Why EoC?

Coaxial cable has been installed in the majority of multi-dwelling buildings worldwide. The in-building coaxial plant, however, is often the source of severe ingress. The issue is magnified in large MDU buildings, especially in older structures across Europe and Asia. The accumulated ingress could cause the DOCSIS

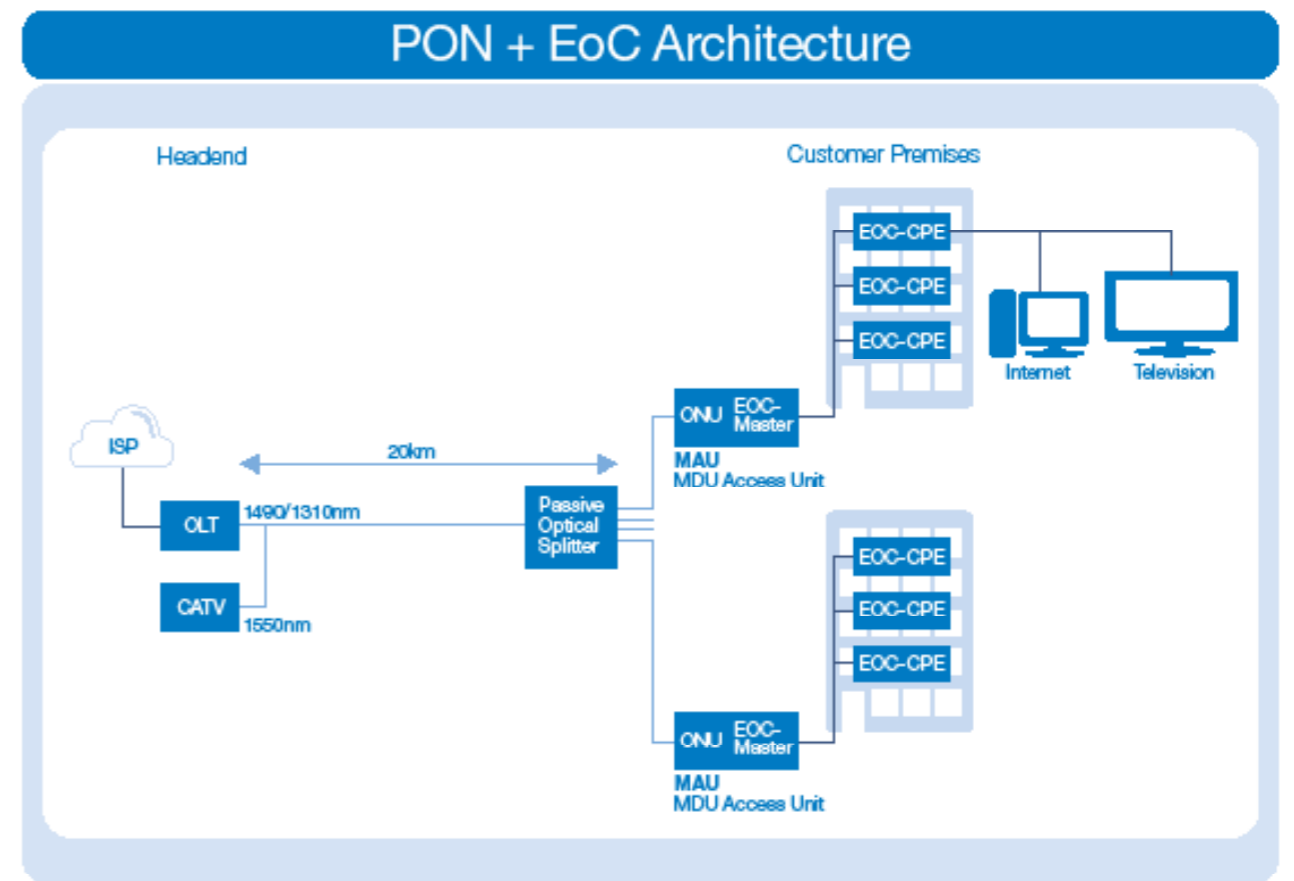


Figure 1. PON + EoC Architecture

Standards	HomePlug AV (2005)	MoCA 1.1 Coax (2007)	HPNA 3.1 Coax (2007)	P1901 Coax (2010)	G.hn (Draft)
Max. Physical Bit Rate (Mbps)	200	175	320	700	1000

**Table 1. PHY bitrates of EoC standards**

system to switch back to lower upstream modulation schemes, or even fail to operate. In such situations, EoC is considered a more rugged solution that offers the ability to overcome many of the ingress issues and uphold the service agreement.

In an attempt to maximize the utilisation of existing coax networks, a number of EoC standards have been defined, including:

- HomePNA (HPNA)
- MoCA (Multimedia over Coax Alliance)
- HomePlug AV
- HD-PLC (by Panasonic).

HomePlug AV and HD-PLC later attempted to combine into IEEE P1901. The number of EoC standards, to some extent, causes confusion to equipment vendors and cable operators, especially when the standards have a similar objective. Yet one main differentiation is the operating frequency range: HPNA 3.1 specifies 4-52MHz, while HomePlug AV specifies 2-28MHz, and MoCA operates between 875-1500MHz.

The lower frequency range has a lower cable loss, but is more susceptible to low-frequency noise. The higher frequency range, although having a higher cable loss, can co-exist with DOCSIS implementation. Thus, depending on the deployment environment, suitable frequency range and so on, the corresponding technology can be selected.

It has been seen that the lower frequency range (HomePlug AV and the later P1901) is a more accepted technology choice

for field deployment in China and Asia, due to the quality of existing coaxial cable plant in old buildings. Another reason for this technology choice is that not many DOCSIS systems have been deployed in these regions, so there are no conflicts with low-frequency band usage.

One could question how EoC can be more resilient in this critical low-frequency band. The answer lies in EoC's flexibility to vary the symbol and modulation rates. When the noise level increases and causes higher bit-error rates, the system can change the modulation scheme from a single 32MHz carrier to 16 x 2MHz carriers. This adaptation allows the system to cope with another 12dB increase in noise or ingress.

In addition to noise tolerance, EoC technology is evolving and promising adequate bandwidth for broadband services. Table 1 shows a summary of the maximum physical bit rates for different EoC technologies. The actual throughput is lower, averaging around 60-80% of the maximum PHY rate. However, the bandwidth available could address typical broadband requirements shared between approximately 30 users.

Recent products complying with the P1901 standard offer 700Mbps PHY rate and 350Mbps actual throughput via coaxial cable. The new G.hn standard, if accepted by the industry, will push the PHY rate to 1 Gigabit/s. This will strengthen the opportunity for EoC as a candidate to provide high-definition video and other bandwidth-hungry applications in an MDU broadband-access environment.

In terms of component availability, which directly relates to cost, there are a number of chipset solutions available on the market.

Standard	HomePlug AV	MoCA like	HPNA	P1901
Solution	Spidcom SPC300	Entropic c.LINK	Coppergate 3210M	Atheros AR7400

**Table 2. EoC chipset solutions for MDU**

Note: there are many more solutions not listed here.

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Many were released around three years ago and are now mature and deployed in volume. Table 2 summarises some of the solutions that particularly cater for broadband access via coax and are well suited to MDU applications.

**Why PON?**

PON (Passive Optical Network) is a rapidly emerging technology for broadband-access application. The advantage of PON is the use of P2MP (Point-to-Multi-Point) architecture, which minimises the number of optical fibre cables required between the head-end and customer premises. As seen earlier in Figure 1, a single fibre from the central office can provide services for multiple MDUs at up to 20km away. This could mean significant cost savings by avoiding the need to lay out new fibres.

The PON architecture, by its nature, is also passive. There are no active components in the network and no power supplies, which mean lower maintenance. Another advantage of PON is its capability to provide high bandwidth and QoS to support multiple services. Two dominant current standards are IEEE GEPON (Gigabit Ethernet PON) and ITU GPON (Gigabit PON). GEPON delivers 1Gbps downstream, typically shared between 32 ONUs, while GPON is specified with 2.5Gbps downstream. There are also new standards for 10Gbps.

Thus, the hybrid of PON and EoC delivers a combination of high performance P2MP optical networks and the resilience of the latest Ethernet over Coax technology, resulting in a cost effective solution for the MDU market.

The major PON+EoC deployments are in Asia. One example is a site of close to 10,000 MDU access boxes, which are progressively being deployed by a local MSO. The operator uses 1x16 optical splits and already has a 50% take-up rate for the installed equipment. The MAU equipment was supplied by PBN (Pacific Broadband Networks). The product uses GEPON technology and, for EoC, has options for either low-frequency band HomePlug AV or high-frequency band MoCA.

PBN first introduced the MAU (MDU Access Unit) concept in 2007. The product addresses quality issues of existing old coaxial plant in the MDU, whilst providing operators with the opportunity to increase their revenue with higher bandwidth.

**RFoG for MDU**

RFoG (RF over Glass) has recently been released under the SCTE-174 standard. RFoG defines a FttH architecture optimised for HFC plant, where the equipment at both the head-end (CMTS) and in the home (cable modem, set-top box) is kept unchanged. As a result, the back office system, billing and provisioning, which is a major MSO investment, is also untouched.

In an RFoG system, the last mile of coaxial cables is replaced by fibres which provide better noise performance. This enhancement will support not only DOCSIS3.0 channel bonding but also QAM64 for higher upstream bandwidth. The RFoG system can co-exist or provide a migration path for future higher bandwidth PON technology.

The key element of RFoG is ONU laser burst-mode capability. The burst-mode laser allows combinations of up to 32 R-ONUs (RFoG ONUs) into a single fibre going back to the optical hub. The laser on-off timing is controlled by the DOCSIS return signal from connected cable modems. This return DOCSIS signal is managed by the CMTS and supports a TDMA (Time Division Multiple Access) mechanism, which prevents two or more lasers being switched on at the same time.

Although RFoG was specified mainly for FttH, the cost of running fibre to every customer premises and the cost of the R-ONU has been an obstacle for the technology to become widespread. This technology, however, could find its niche market within the MDU application. Here, it makes a lot of commercial sense as multiple residents within the building share the cost of the R-ONU.

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Figure 2 shows the architecture for FttM using an RFoG burst-mode transmitter inside the MDU Access Unit (MAU). The architecture is a Passive Optical Network, with no active components between the central office and the MDUs. The PON split is typically between 1x8 and 1x16, which means around 250 - 500 homes passed, based on approximately 30 homes per MDU.

In the forward path, CATV is carried over a 1550nm wavelength, which could use an EDFA (Erbium-Doped Fibre Amplifier), depending on the optical budget. The MDU Access Unit incorporates a forward-path receiver and RF amplifier, which outputs high RF levels (normally over 100dBµV) for in-building CATV and forward-path DOCSIS distribution. The high RF output requirement is important to eliminate or minimise further RF amplification within the building.

In the return path, DOCSIS cable modems within the MDU are combined and input into the return burst-mode transmitter (RFoG TX in the diagram). The return path is carried on either 1610nm or 1310nm wavelengths. The 1610nm wavelength allows co-existence or future upgrade to EPON/GPON technology.

FttM using RFoG offers a real cost saving as it minimises the number of optical fibres required from the central office, whilst maximizing the utilisation of existing in-building coaxial plant. All of the benefits of RFoG are inherited including re-utilisation of the back office, and the existing mature low-cost cable modems.

Some RFoG-to-MDU deployments have been started in the US. Experience from these deployments shows that a number

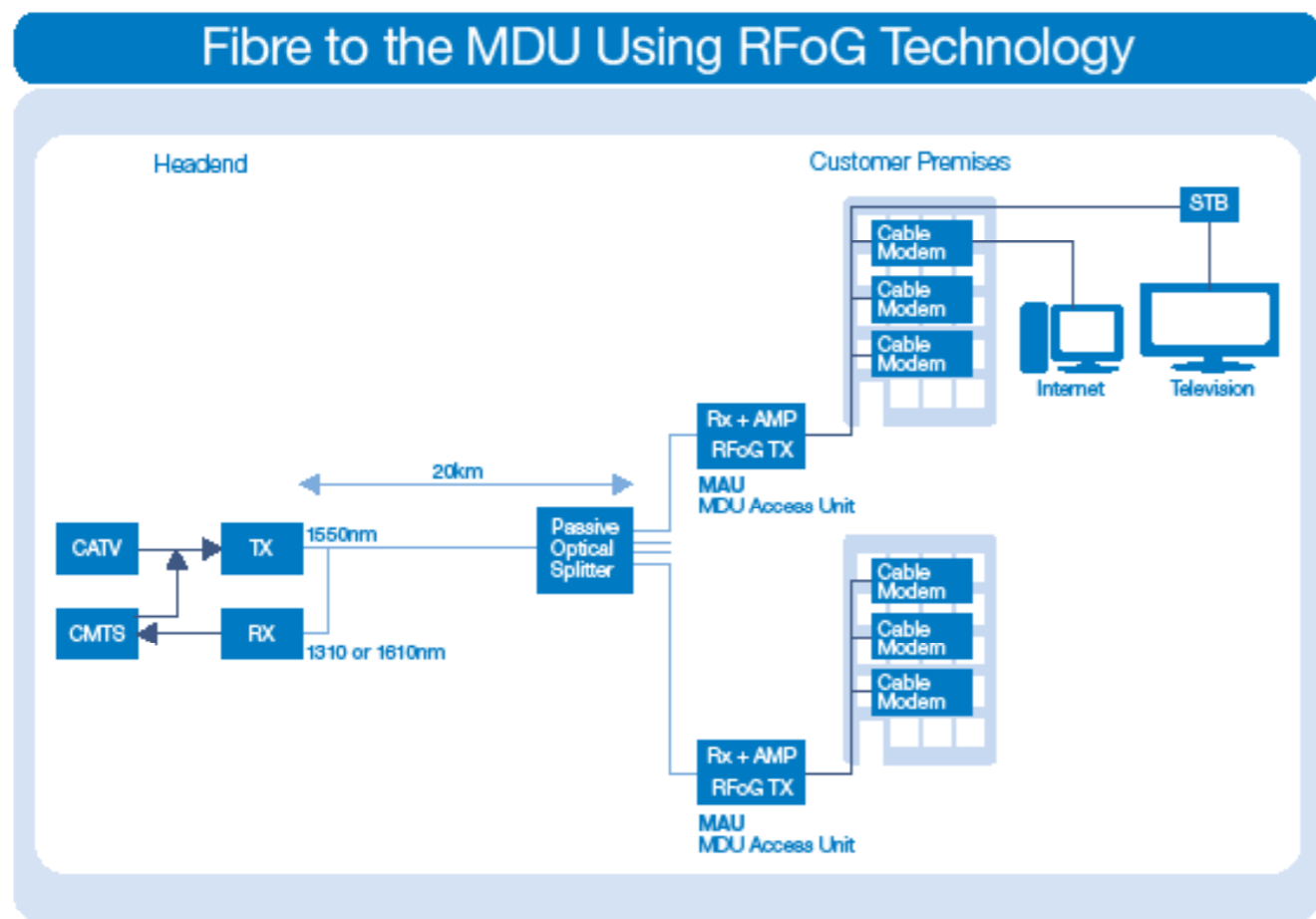


Figure 2. Fibre to the MDU using RFoG technology

of specifications need to be adjusted from the RFoG SCTE-174 standard to suit MDU deployment. The MDU environment requires much higher RF output, higher output tilt, but lower nominal RF input level into the MAU. The Turn-On/Turn-Off specification for the burst-mode return transmitter also requires adjustment for a lower range.

For example, the MAU equipment, supplied by PBN, has a 114dBµV output and up to 13dB output tilt, compared to 77dBµV and 5dB specified for a typical RFoG R-ONU. The unit can also handle 15dBmV nominal RF input level per channel. The PBN MAU modular platform has the flexibility to support either PON+EoC or RFoG architecture.

While large-scale deployment of RFoG is currently still challenging, the use of RFoG technology in an MDU application has the momentum, is cost efficient and is the first economical step towards an all-fibre network.

### Conclusion

Having discussed some of the architectures for Fibre to the MDU, it is apparent that, with the right choice of products and technology, cable operators can have a cost effective solution that provides higher bandwidth and added services to MDU residents.

The PON+EoC integrated solution overcomes problems associated with the less-than-optimal coaxial plants found in many regions around the globe. The MDU RFoG solution ensures lowest investment by preserving MSOs' existing back office and end equipment. Obviously, there will be many more challenges in rolling out the described systems, but the rewarding opportunity of Fibre to the MDU should not be overlooked.

