A PBN White Paper

Is Radio Frequency over Glass (RFoG) the Solution for CATV Operators?

RFoG is worthy of serious consideration for cable operators looking to deploy FTTH, especially in greenfield applications.

This white paper is a guide for information purposes only.

Author: Mr. Peter Saglietti
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Pacific Broadband Networks
8-10 Keith Campbell Court
Scoresby Victoria 3179 Australia
Phone: +61 3 9780 5100
Fax: +61 3 9763 5522
www.pbnglobal.com

Mr. Peter Saglietti
Chief Technology Officer
Pacific Broadband Networks (PBN)

Mr. Peter Saglietti, the original Founder of PBN, has undertaken technical studies in Australia. He is currently a serving member of the USA SCTE, a Patron member of the UK SCTE and member of the IEEE and SCTE RFoG standards working group.

The majority of Peter's professional working life has been involved in developing products and systems in CATV RF and optical transport for both HFC and FTTH. In the late 80s, he was involved in the development and utilisation of fibre optics in CATV networks with Telecom Australia Research Laboratory and Anixter International. Later on in the early 90s, he was part of the initial FTTH development trials in Australia involving NEC and British Telecom.

Peter previously held the position of General Manager within a prominent division of Pacific Dunlop Limited. After a management buy-out in 1997 and until recently he held the position of Managing Director of PBN, where he was responsible for establishing and growing the company as an industry leader providing comprehensive broadband distribution and access solutions to tens of millions of subscribers served by hundreds of headend facilities worldwide.

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Introduction

The humble Community Antenna Television (CATV) system may be about to get a major makeover that is way beyond what one could have imagined in the 60s and 70s. Some of us can still remember in the 80s when 50 Radio Frequency (RF) amplifiers cascaded and FM microwave links were common place to connect headend systems and deliver 30~70 channels to the home.

The 90s did herald the start of Hybrid Fibre Coax (HFC) networks, but today a combination of fibre and coax still remains the industry's primary way of delivering multiple television channels, internet and voice services. The term Broadband today is widely used, but can be traced way back to the early days of CATV.

Broadband networks transport two dimensional multiplexing in time and in frequency. Data is transmitted and received using multiplexed RF channels as well as Time Division Multiplexing (TDM). The recent introduction of optical Wavelength Division Multiplexing (WDM) allows many hundred more frequencies to be carried in the optical domain, transmitting a combined 32+ wavelengths onto a single fibre. The introduction of optical transmission to CATV with emerging technologies such as RFoG could be considered as three dimensional broadband delivering not hundreds but thousands of services to every home. Figure 1 illustrates how HFC is utilising TDM, FDM and WDM.

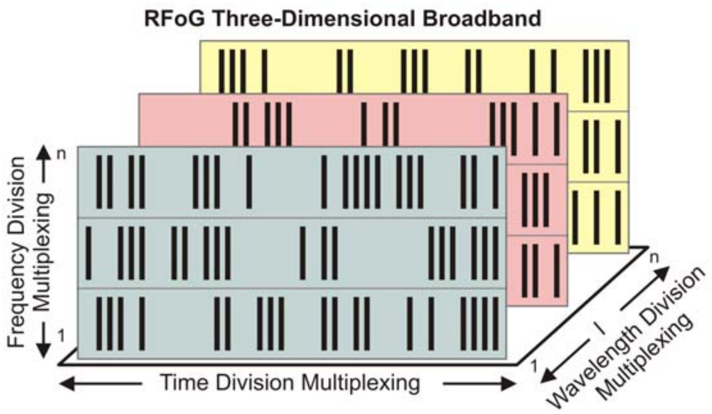


Figure 1 – RFoG Three-Dimensional Broadband

Looking at modern HFC networks today, optical fibre is reaching between 400~1500 homes per node, typically using two fibres per optical distribution node placed well within one mile of the customer. Newly-built HFC networks are migrating fibre much deeper in the network and much closer to the home. The term deep fibre sees homes served by localised nodes, from 50~400 homes per node. Many cable operators serving high density environments are now deploying fibre directly to the basement of high-rise apartment buildings.

The world has embraced FTTH like no other terrestrial-based transmission medium. More to the point, the consumer wants fibre to their home. It makes no difference if it is twisted pair ADSL2+ or coax; consumers, developers and governments only want fibre. When asking the question, "why FTTH?" there is always a common response; in the minds of customers, fibre is faster and carries more services. With this in mind, let's have a close look at which FTTH technologies are commercially available today and which technology is the best-fit to evolve the modern day HFC network to an all fibre network.

FTTH delivery architecture alternatives

During the selection process of FTTH architectures, there are many factors in play for consideration. Greenfield applications are an excellent FTTH choice for first phase deployments, whereas, brownfield developments have limited access to the last mile to the home.

CATV operators have significantly different headend setups to that of the traditional Telcos or start-up operators and the legacy infrastructure drives the selection of FTTH technology deployments. For example, telcos still rely heavily on switched voice networks SDH backbone ATM equipment.

Service and access to the customer are concentrated via star-based architecture to local exchanges that service typically around 20,000 customers. CATV operators tend to have a greater degree of IP-based headends capable of deploying VoIP, video and internet services with strategically located sub headends or hubs covering large metropolitan areas. Fibre feeder networks from the hubs are typically star topology to localised nodes. Beyond the node location, a coaxial tree and branch topology is used to deliver the services to the home. Sub headends or hubs can serve a large number of business or residential communities. In some cases, up to 100,000 subscribers are connected back to a hub location.

Point-to-Point Active Ethernet. One or two fibres are deployed directly from a local headend exchange to each home or business premise. At the premises, an Optical Network Unit (ONU) converts the optical signal via fibre back to Ethernet and RF whilst, at the headend, the optical signal via fibre is converted to Ethernet and aggregated through a series of switches to 10Gbps optical backbone Wide Area Network (WAN). Video content referred to as RF overlay is amplified by an EDFA and injected onto the same fibre utilising a WDM.

Comments. This architecture is very popular in Europe; this approach offers the greatest longer term upgradability of all the Passive Optical Network (PON) solutions. The use of outside splitters offers the greatest flexibility and does not restrict future technology improvements compared to shared fibre architecture. In many ways, this approach reflects the evolution of the telephony shared party lines quickly giving way to a single twisted pair to every home point-to-point. A downside is the construction cost due to the larger number of optical fibres and the need for significantly more hardware in the headend.

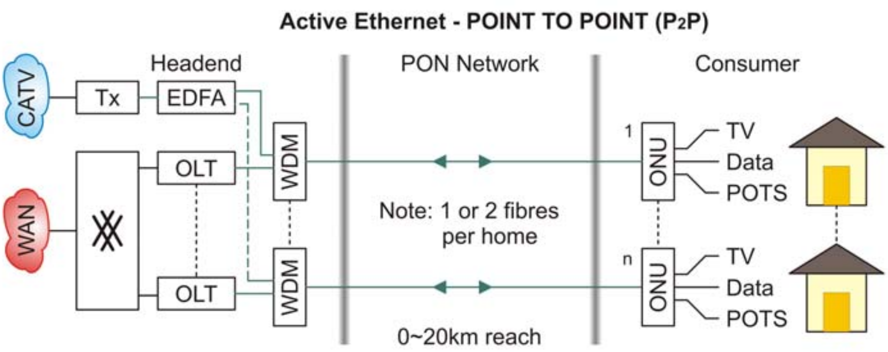


Figure 2 – Active Ethernet – POINT TO POINT (P2P)

Point-to-Multi-Point EPON, GPON. This approach requires a single fibre feeder to be shared with multiple subscribers, typically up to 32 with CATV overlay or 64 without. The ONU in the home or business converts the optical signal back to Ethernet and RF resulting in similar services delivery to P2P. At the headend, both Ethernet and RF are combined via an Optical Line Terminal (OLT), which converts Ethernet and RF onto a single optical fibre that can service up to 64 ONUs.

***Comments**.* This architecture is by far the most popular; driven purely by significant cost reductions in fibre utilisation, not only at plant level, but also at the headend. Hardware is significantly reduced with OLT ports supporting 64 customers. The IP aggregation is part of the OLT functionality and this significantly reduces the amount of Ethernet switches needed in the headend. A downside is that future upgrades to greater bandwidth may be limited due to multiple access on a shared fibre.

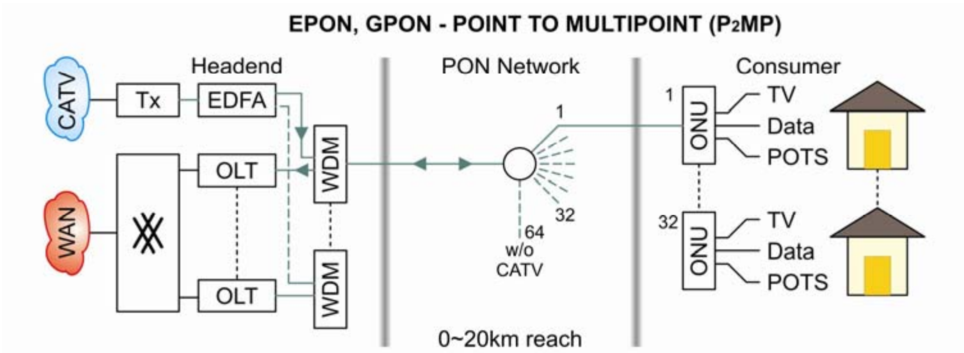


Figure 3 – EPON, GPON – POINT TO MULTIPOINT (P2MP)

Point-to-Multi-Point RFoG. Developed with the members of the SCTE working group, RFoG is currently in the final phase of standardisation; US SCTE specification IPS SP910 is specifically developed to meet the needs of CATV operators. RFoG is similar at the outside plant level supporting up to typically 32 subscribers on one fibre core; one single mode feeder fibre from a headend, exchange or optical distribution node can serve up to 32 ONUs. One of the benefits of RFoG is that the technology has been designed specifically for cable operators deploying HFC, supporting traditional HFC networks, DOCSIS modems supporting IP services and STB return path and, at the same time allow EPON and GPON ONUs to utilise the same PON by means of different wavelengths on the same fibre.

Comments. RFoG offers a cost-effective migration to FTTH, leveraging the benefits of DOCSIS 2 and DOCSIS 3 whilst supporting EPON and GPON based architectures. Service capacity, speed and flexibility are still better than FTTH networks operating today. This is largely due to the investment in headend service delivery technology, extensive expertise in delivery of video content and the utilisation of DOCSIS 3, which now allows HFC networks to deliver IP services at similar speeds close to 100Mbps via RFoG ONU. A downside is that RFoG only makes sense if using DOCSIS technology. Ethernet performance is limited to DOCSIS cable modem versions as deployed.

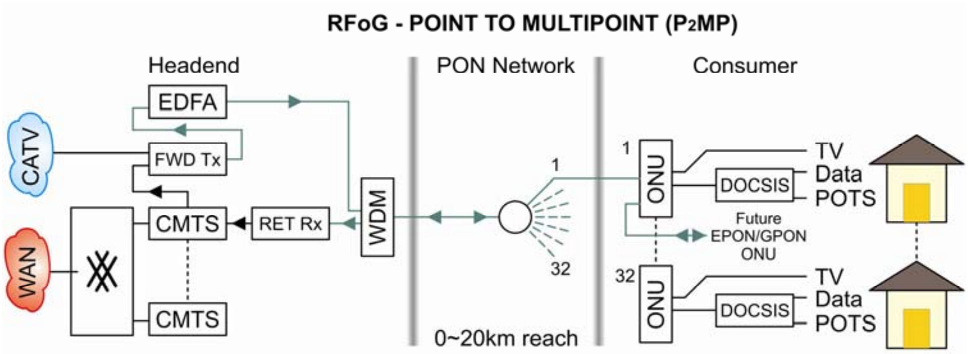


Figure 4 – RFoG – POINT TO MULTIPOINT (P2MP)

RFoG logical evolution to all fibre access

Cable networks' outside plant upgrades are constantly evolving and utilising existing headend and ONU hardware, hence increasing bandwidth, reducing subscribers serviced and reducing RF active components in the outside plant. The deployment of fibre deeper in the network, reducing the number of subscribers served by RF amplifiers and coaxial plant, is now moving closer to 32 subscribers per node than ever before.

The industry may still be a few years off this but, if faced with the task of extending existing HFC to new developments or undertaking critical rebuilds, why not deploy RFoG today?

- RFoG is FTTH satisfying developers, law makers and customers.
- RFoG utilises the existing headend infrastructure BSS OSS, time-to-market is equivalent to existing HFC, and operational deployment and maintenance expertise is similar to existing skill-sets with cable operations.
- RFoG deployment allows future EPON and GPON solutions to utilise simultaneously the same optical fibre PON, hence future-proofing networks for many decades to come.
- Customer premises equipment can be re-used. STBs, DOCSIS cable modems and video content over RF analogue or QAM is expanded to 1GHz. Multiple STBs and DOCSIS cable modems are supported within the existing home MDU wiring.

Considerations

- FTTH servicing areas may be a considerable distance from the closest hub or headend, typically 1~20km. Availability of existing fibre may be limited to only fibres terminating to the closest node.
- Utilising existing arial strand or underground ducting will significantly reduce the fibre access construction efforts. The existing HFC node infrastructure closest to the FTTH servicing area will also lead to cost savings and dramatically improve the activation time by utilising existing plant and hardware.

Aggregation of the 32 way PON to a localised optical RFoG node (as illustrated in figure 5) provides a flexible solution of combining 32x4=128 RFoG ONUs onto existing fibres servicing localised HFC nodes. This technique can be configured in many combinations to suit both aerial and underground constructions.

Where possible, fibre aggregation up to 32 or 128 fibres at splice locations or optical splitter points close to the existing HFC node will provide maximum flexibility. In the initial deployment phase, the 32-way PON's are aggregated and combined using an ODN-RFoG. This removes the need to install fibre feeders back to the headend.

By using WDM technology, the existing HFC node fibres can be utilised; in time, the CATV operator may consider running larger fibre counts, e.g. 48/126/255 to the PON splitter aggregation point, allowing rapid expansion of FTTH within the servicing area or P2P service for high-end customers.

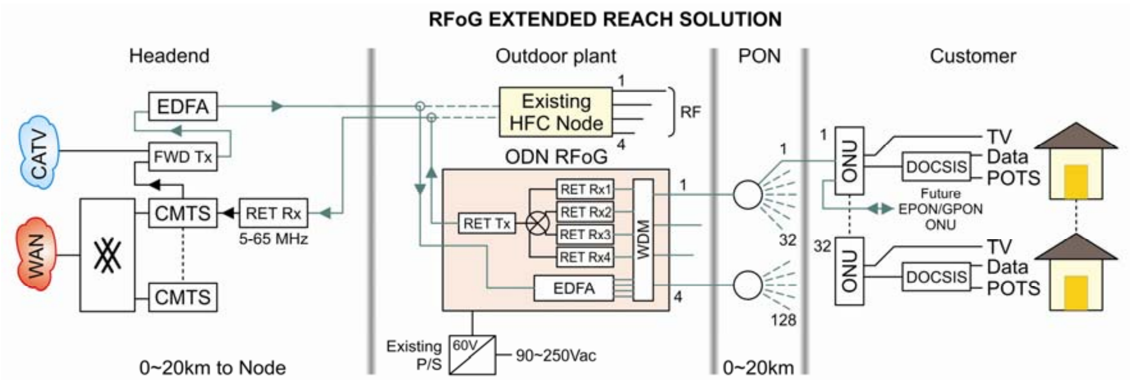


Figure 5 - RFoG EXTENDED REACH SOLUTION

RFoG technical performance consideration

The following technical parameters have been proposed to members of the US SCTE standards group.

Headend

Forward path optical wavelength CATV DOCSIS downstream channels	1550nm ITU
EDFA typical output to support 32-way PON	+ 16dBm
Return path receiver frequency	5~30MHz, 5~42MHz, 5~65MHz
Return path wavelength preferred *	1610nm, 1590nm, 1310nm
Return optical level to receiver	-27 to -10dBm
Typical RF output from return path receiver	20dBmV

Outside Plant

Optical PON splitter ratio	1 to 32
Fibre	SMOF 1310nm or 1550nm low dispersion
PON reach	1~20km

ONU

Optical Forward path receiver input level	0 to -6dBm
RF output	20dBmV
RF output frequency	45~1000MHz, 54~1000MHz, 85~1000MHz
RF return path level from DOCSIS modem	+30~50dBmV at 4 ch. 64QAM, 6 or 8MHz
Optical return output	0 to +3dBm burst-mode DFB
Optical return output wavelength select *	1610nm, 1590nm, 1310nm
Optical EPON GPON bypasses	1310/1490nm

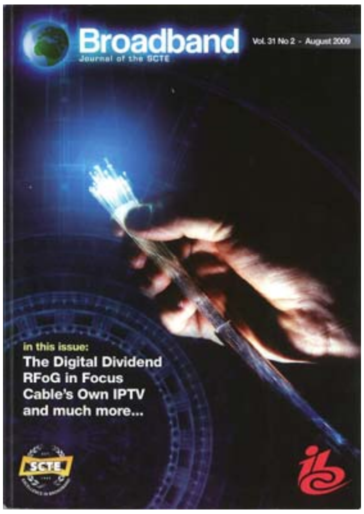
* Note - 1310/1490nm is reserved for EPON and GPON services. 1577nm is reserved for future 10Gbps PON systems.

Conclusion

RFoG is worthy of serious consideration for cable operators looking to deploy FTTH, especially in greenfield applications. SCTE standards due for release in 2009 will support the widespread deployment ensuring interoperability between different vendor equipment. It is just one more step to all optical broadband networks. HFC networks around the world continue to deliver the best value for money. RFoG may well be the soft-start transition for which the industry is looking.

Broadband – Journal of the SCTE

In the August edition of Broadband, Mr. Peter Saglietti's White Paper titled 'Is Radio Frequency over Glass (RFoG) the Solution for CATV Operators' has been published. 'Broadband' is the SCTE's quarterly journal.



Download the Journal at:

http://www.scte.org.uk/members/ctearchive/vol31_no2.pdf

The article starts on page 50 and ends on page 54.

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For further information about this White Paper, HFC to FTTH, contact Mr. Peter Saglietti of PBN psags@pbn.com.au.

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