EXECUTIVE BRIEF

PLANNING TODAY FOR NEXT-GEN DOCSIS®?

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ARRIS

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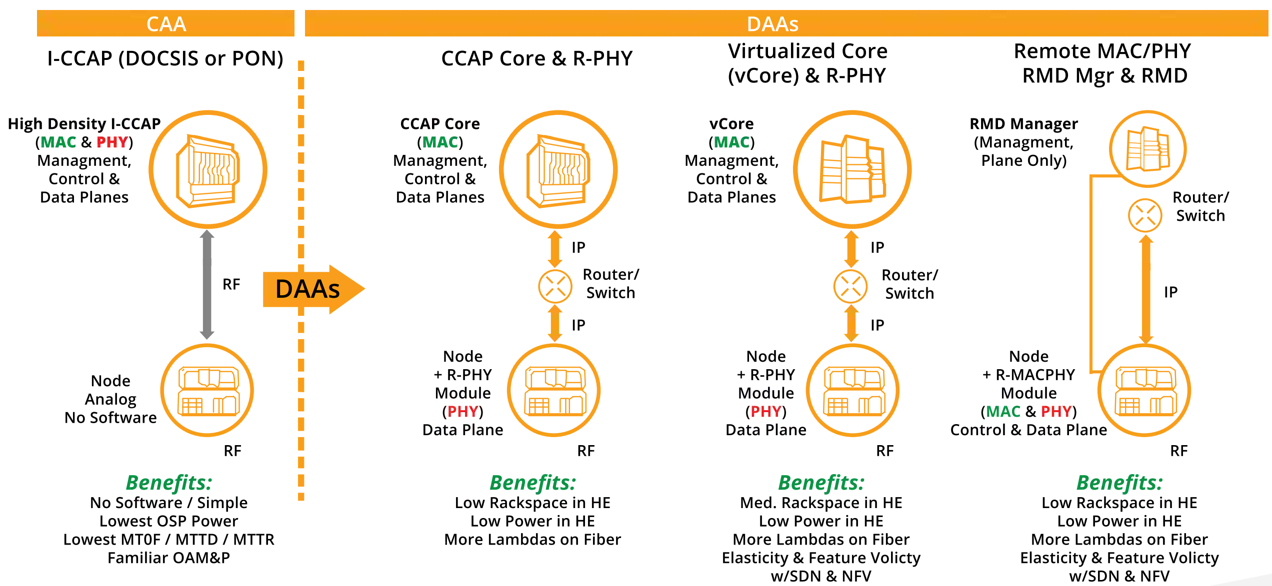
This is an exciting time for DOCSIS® evolution. The bandwidth usage in the upstream and downstream is growing every year. A recent traffic engineering study by ARRIS shows a compound annual growth rate (CAGR) of 30% in the upstream and a CAGR of 40% in the downstream. The growth is driven mostly by an increase in consumer video streaming with the availability of OTT services, video chat applications and high-speed broadband. The traditional integrated CCAP (I-CCAP) architecture is still viable for many MSOs, but as the bandwidth requirement grows, the headend rack space, cooling, power and network efficiency requirements increase proportionately with it.

The Distributed Access Architecture (DAA) approach has emerged to address the challenges brought about by the increase in video consumption and the need to deliver more bandwidth to support the trend. MSOs can implement a DAA with either Remote PHY (R-PHY) or Remote MACPHY (R-MACPHY). Both the architectures offer many benefits and ARRIS has been strongly focused on providing cutting-edge technology to support each type of architecture so MSOs have more choice when addressing their own unique needs.

This article will explore next-gen variants of DOCSIS architectures like Remote PHY and Remote MACPHY, as well as upcoming technologies for symmetric services such as Full Duplex DOCSIS (FDX) and those that extend the life of HFC, including Extended Spectrum DOCSIS.



MAC = Packet-level processing
PHY = Bit-8F level processing

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Remote PHY (R-PHY)

In Remote PHY architecture, a traditional I-CCAP is divided in two parts:

1. The upstream and downstream RF functionality is placed in an R-PHY device module in the fiber node
2. The MAC functionality of an I-CCAP is maintained in a CCAP core. CCAP core uses digital optics to communicate with an R-PHY device module

At a high level, the CCAP core maintains the management, control and data plane functionality while the R-PHY device has only the RF functionality. The core and RPD communicate with each other using a downstream external PHY interface (DEPI) and an upstream external PHY interface (UEPI).

The R-PHY architecture enables MSOs to overcome various networking and infrastructure challenges like limited headend rack space, power Lambda exhaustion on DWDM fibers and SNR issues. R-PHY helps minimize the effects of these challenges by leveraging digital optics and IP convergence. For an R-PHY system to work in perfect harmony, the CCAP core and RPD must be synchronized with a 1588 grandmaster clock. In R-PHY systems, a core can be virtualized and run on a commercial off-the-shelf (COTS) server as a virtualized core (vCore).

With the advantages of R-PHY, there is the possibility of interoperability between the R-PHY core and Remote PHY module. ARRIS has actively participated at multiple interops organized at CableLabs to bring vendors together in an effort to facilitate the interoperability across the industry.

In the future, ARRIS will also support dual configurations of I-CCAP and CCAP core functionality for the MSOs that plan to implement both a centralized and distributed architecture.

Remote MACPHY (R-MACPHY)

Remote MACPHY architecture carries the complex MAC and PHY functionality to the fiber node. This architecture distributes the centralized service group support of I-CCAP to one or two service groups supported per fiber node. It has multiple advantages for the headend such as reducing required rack space and lowering power utilization with only routers and switches placed in the headend. This architecture also enables usage of digital optics between the headend routers and optical node, and using virtualized management for the R-MACPHY modules. R-MACPHY does not have a strict IEEE 1588 timing requirement between headend and the R-MACPHY node, however timing may be required in the case of phase and frequency synchronization for mobile backhaul (MBH).

As with its participation in R-PHY interoperability efforts, ARRIS is actively contributing to the CableLabs R-MACPHY committee meetings.

Full Duplex DOCSIS (FDX)

The Full Duplex system is becoming a reality in the world of DOCSIS as evidenced by the availability of Full Duplex DOCSIS. FDX is an extension to the DOCSIS 3.1 specification, primarily to enable symmetric upstream and downstream bandwidth. Full Duplex technology is not new to the communications industry, but is novel to the world of DOCSIS. FDX is realized by expanding the upstream spectrum from 42 MHz to 684 MHz. The objective is to enable a service group to have bandwidth of 5 Gbps in the upstream and 10 Gbps in the downstream. An important point to note is that the simultaneous data transmission is from the fiber node's point of view and not the cable modem.

The requirements to be able to leverage FDX include:

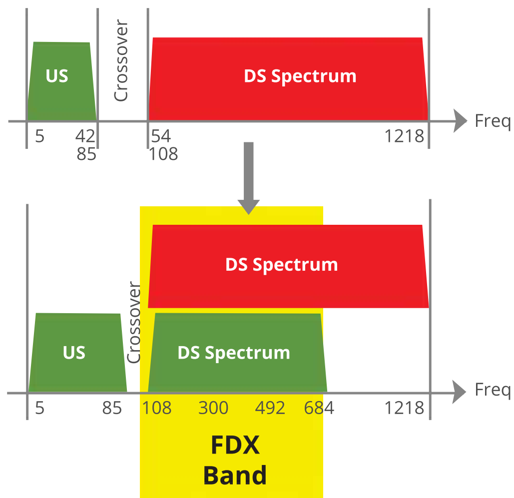
a. Distributed Access Architecture

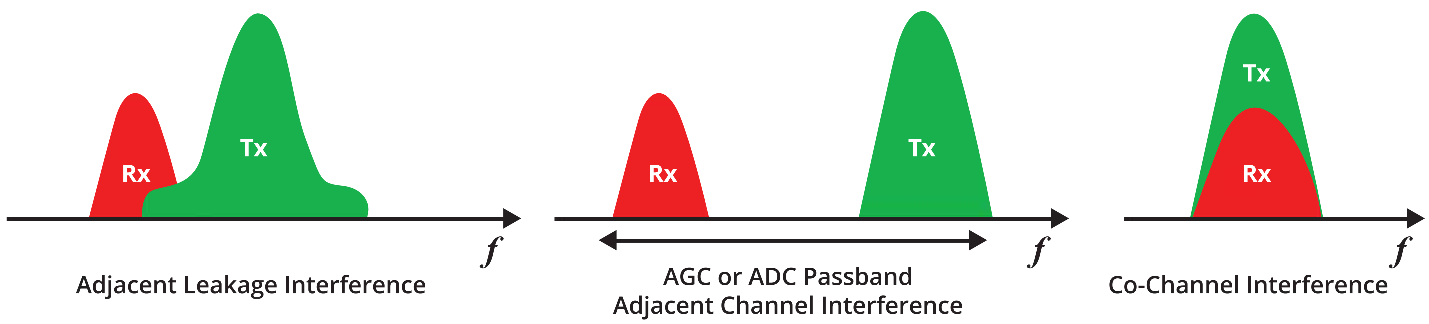
b. Node + 0 outside plant (i.e. zero amplifiers)

c. Echo cancellation for noise mitigation

Moving forward, an R-PHY system will be the boilerplate for FDX based nodes, since FDX involves major changes in the DOCSIS 3.1 MAC and PHY specifications. An important point to note is that the simultaneous transmission and reception of signal is from the fiber node's perspective, and each cable modem (CM) with FDX capability will still be operating in Frequency Division Duplex (FDD) mode.

- FDX uses multiple complex algorithms including a sounding algorithm. Sounding is used to identify the groups of modems that may interfere with each other if they are transmitting and receiving in the same frequency band at the same time. These groups of modems are called interference groups (IGs). IG is a PHY layer concept.
- A Transmission Group (TG) comprises one or more IGs and can be considered as a super-set of IGs. This is a MAC layer concept.
    - o Each TG uses some channels in the FDX band as upstream channels and other channels as downstream channels.
    - o A TG may use a part of the spectrum for upstream operation and a different TG may use that same spectrum for downstream operation.





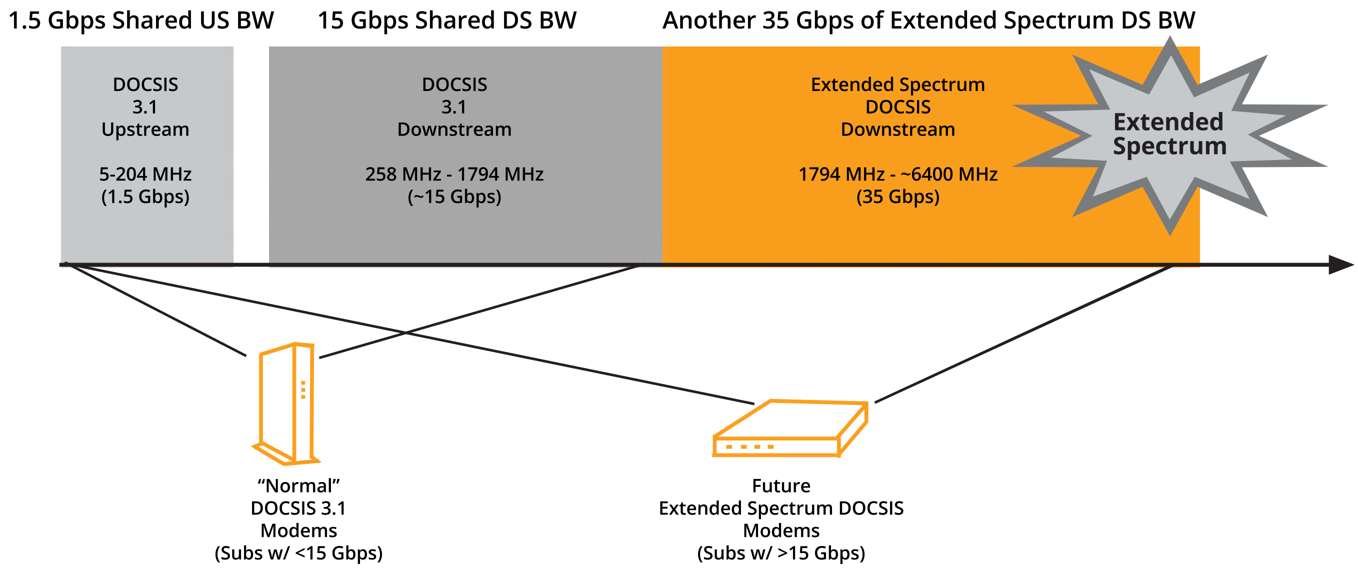
The operation of upstream and downstream spectrum within the FDX band can also be dynamically changed within a TG. FDX becomes more complicated with the use of RF echo cancellation techniques to mitigate the impacts of co-channel interference (CCI), adjacent channel interference (ACI) and adjacent leakage interference (ALI) because of upstream transmissions from CMs.

- **ACI** occurs when a transmitter's energy and a receiver's tuned-to energy are within the AGC or ADC passband, even though the transmitter and receiver are outside of each other's frequency band.
- **ALI** occurs when energy is being received at a receiver and a transmitter injects energy next to the receiver's frequency band, the tails of the transmitted energy encroach upon the receiver's frequency band.
- **CCI** occurs when a transmitter injects energy on the same frequency band where a receiver's tuned-to energy is being received.

ARRIS has been actively participating in CableLabs committees to make FDX technology a reality.

Extended Spectrum DOCSIS

As bandwidth needs continue to grow at a rapid pace fueled by the advent of new video-based applications, we can benefit more from DOCSIS. ARRIS developed the idea to extend the spectrum boundaries of today's DOCSIS 3.1. MSOs can choose to leverage the existing HFC plant by extending the spectrum that supports DOCSIS 3.1 OFDM downstream blocks beyond the 1.794 GHz limit defined in the DOCSIS 3.1 specification. The highest frequency in the spectrum can be 3 GHz, 6 GHz, 12 GHz or higher. Of course, a direct function of more spectrum is more bandwidth.



Extended Spectrum DOCSIS systems will require several changes to a typical HFC network. The HFC network must be upgraded to allow operation of higher frequency signals from headend to the CM. This technology has a very flexible design and can be used in a centralized or distributed architecture. It is expected to work well with amplitude modulated optical signals in the fiber portion of the HFC network. However, non-linear optical effects resulting from interaction between Lambdas on lengthy wavelength division multiplexed fiber may reduce the SNR and throughput of the Extended Spectrum DOCSIS system. This problem can be solved in an R-PHY or R-MACPHY architecture because the digital optics will minimize SNR degradation because of non-linearity in the fiber. Also, DAA will permit more Lambdas on the fiber yielding more bandwidth capacity.

Initial analysis has shown that this technology is feasible and may help MSOs design their networks for the future. Extended Spectrum DOCSIS may also be able to be used with Full Duplex DOCSIS technology.

*For more information, please visit **arris.com.***

References

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[2]. T. Cloonan, et.al, "Using DOCSIS to Meet Larger Bandwidth Demand of the 2020 Decade and Beyond," ARRIS White Paper