Remote PHY transforms your cable access network

Introduction

An extension of DOCSIS 3.1, Remote PHY (Physical) is the product of cable operators asking the industry to help them overcome the limitations of analog fiber and break through the Hybrid Fiber-Coaxial (HFC) bottleneck. In its most basic form, Remote PHY (R-PHY) unlocks major bandwidth increases in existing access networks by splitting Cable Modem Termination System (CMTS) functions so that the Converged Cable Access Platform (CCAP) core and physical-layer functions run separately in different locations.

With Remote PHY, CCAP core routing can run out of larger hubs (or even vCCAP instances in a data center), while Quadrature Amplitude Modulation (QAM) and Orthogonal Frequency-Division Multiplexing (ODFM) modulation get pushed out to Remote PHY Devices (RPDs) located nearer to subscribers.

Let's take a closer look at how Remote PHY transforms your access network.

Contents

Introducing Remote PHY 2.0

In this paper we refer to the existing R-PHY technology and specifications as R-PHY 1.0 or simply 1.0 “Remote PHY 2.0” is nothing more than a common label applied to the set of new R-PHY architecture options proposed in this paper. We don’t claim that any of these features cannot be added to existing specifications and products without such a label. We believe, however, that there are tangible benefits and a convincing argument for separating these options from current R-PHY technology and packaging them under a new version label. The primary concern is the ability of the existing products to support these new options.

The following factors also need to be considered:

- The proposed features are interdependent. For example, the proposed model-driven telemetry relies on RPD supporting the data-driven control plane.

- The proposed technical solutions do not constitute incremental development. They offer replacement for currently utilized techniques and may not provide backward compatibility.

- It is beneficial to logically separate these options because of the large scope of changes to the involved software infrastructure.

Remote PHY enables “fiber deep” architectures that push digital fiber out much closer to home

With R-PHY, you can replace analog HFC fiber nodes in the last mile with nodes connected to next-generation CMTS platforms at hub sites. You eliminate the analog fiber network connecting hubs to nodes, replacing it with a less-expensive, higher-quality 10-Gbps or 100-Gbps Ethernet network. With R-PHY, cable operators can now deliver capacity and Gigabit service tiers on par with any pure-fiber competitor at a fraction of the cost of ripping and replacing the existing HFC plant.

The R-PHY Control Protocol

In R-PHY Architecture, the integrated CCAP is separated into two distinct components.

The first component is the CCAP Core. The second component is the RPD.

The CCAP Core inherits all I-CCAP functions except for the PHY layer, which is implemented in the RPD. The CCAP Core and the RPD communicate over a permanent Internet Protocol (IP) connection.

Remote PHY Node eliminates many inefficiencies of analog optics

Today, cable providers need racks of QAMs stacked together, converting digital services for analog optical transmission. Analog optics have limitations. They can't transmit over long distances, and they generate significant "noise" in the network, reducing quality and limiting capacity. When you deploy R-PHY devices close to customers, you eliminate analog transmitters and receivers and replace them with digital fiber connections, removing most of the noise from your access network.

You can use higher-order modulation schemes to deliver much more bandwidth – scaling from a maximum 256 QAM modulation today to 1,024 or 4,096. Add it up, and you can boost data rates over existing HFC infrastructure by 50 percent at a fraction of the cost of deploying a full Fiber to the Home (FttH) architecture.

Remote PHY boosts capacity and lowers costs

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R-PHY is a perfect fit for cable operators

Studies show networks are evolving faster today than in the previous decades, while their Operational Expenditure (OPEX) and Capital Expenditure (CAPEX) are continually reduced. Automation and Virtualization are the key evolutionary drivers.

An R-PHY Control Protocol transition that depends on YANG models and is widely deployed with standard-based protocols will align the R-PHY with modern cloud-native technologies.

The next steps for Remote PHY Technology 2.0

Remote PHY technology has finally entered the phase of wide-scale deployments. Currently there are several cable operators providing commercial services based on R-PHY technology to hundreds of thousands of subscribers. The multi-year R-PHY standardization efforts led by CableLabs® are slowly concluding and soon the R-PHY project at CableLabs® will enter the maintenance phase. The working group's focus will shift toward fixing specification bugs rather than defining new functionality.

The confluence of these events creates a perfect opportunity to take a step back and perform a critical review of the R-PHY technology, assess its weaknesses and gaps, and devise a strategy to best address these issues. This paper presents a menu of options for several selected new R-PHY features. Our intent is to initiate a conversation within the industry about the future direction of R-PHY technology. Therefore, the list of R-PHY 2.0 features discussed within this paper is open to further additions and changes.

Cloud-friendly control plane

In this section we propose a strategy to replace the main control protocol deployed in R-PHY 1.0 architecture. First, we describe the existing R-PHY control protocol and analyze its strengths and weaknesses. Later we detail the approach to upgrade the control protocol and take a closer look at how to minimize the transition impact on the existing R-PHY system. Finally, we explain the technical and business benefits of the proposed transition.

What is R-PHY Control Protocol?

In a R-PHY Architecture, the integrated CCAP is separated into two distinct components. The first component is the CCAP Core. The second component is the RPD. The CCAP Core inherits all I-CCAP functions except for the PHY layer which is implemented in the RPD. The CCAP Core and the RPD communicate over a permanent Internet Protocol (IP) connection.

The relationship between the CCAP Core and the RPD resembles a master-slave communication model. The direction of control is from the CCAP Core to the RPD. The CCAP Core remotely controls the functions of the RPD through a protocol which we refer to as the R-PHY Control Protocol.

The R-PHY Control Protocol incorporates all elements of the FCAPS (Fault, Configuration, Administration, Performance, Security) management framework. In this context, the CCAP Core acts as the Network Management System and the RPD acts as the Managed System. There are, however, several important differences in requirements for a typical FCAPS operation and for a R-PHY Control Protocol, with the Core and RPD having a much tighter coupling than a typical FCAPS manager and client. In many instances, the CCAP Core and the RPD operate with a common set of configuration parameters and state information. Whenever the operator, or internal processes in the CCAP Core, impose changes to the values of these parameters or state variables, the Control Protocol needs to coordinate

Benefits of Cisco R-PHY

Simple, low-cost Passive Optical Network (PON) transmission

Reduced invenstment cost including OPEX and CAPEX

Low-cost, highly stable Cisco GS7000 node

Reduced CMTS hardware complexity

No restriction on Converged Interconnect Network (CIN)

Futureproof architecture that is easy to migrate

End-to-end QoS assurance provided by DOCSIS

Support for all DOCSIS services

Support for existing DOCSIS network provisioning system

High-access bandwidth

them between the systems, sometimes with tight real-time constraints. For example, when the configuration of a downstream profile changes on an OFDM channel, the change needs to be enacted in both systems by a detailed procedure prescribed by the Control Protocol.

The R-PHY architecture incorporates a great deal of flexibility in how the CCAP is functionally decomposed into a set of independent CCAP Cores. For this reason, each RPD is required to provide service to multiple (from one to 10) CCAP Cores.

The R-PHY benefits to cable operators

This paper demonstrates that each one of these options is worthy of consideration by cable, and that when combined they provide value greater than the sum of the parts. Taken together, these technical improvements constitute a new generation, Remote PHY 2.0.

Enabling automation

Studies show networks are evolving faster today than in the previous decades, while their Operational Expenditure (OPEX) and Capital Expenditure (CAPEX) are continually reduced. Automation and virtualization are the key evolutionary drivers. An R-PHY Control Protocol transition that depends on YANG models and is widely deployed with standard-based protocols will align the R-PHY with modern cloud-native technologies.

It helps address the many R-PHY Control Protocol (RCP) 1.0 issues explained earlier in the paper. Very few automation tools support Generic Control Plane/R-PHY Control Protocol (GCP/RCP). Many existing cloud automation tools are available, and their Application Programming Interfaces (APIs) are YANG based. Thus, transitioning to a 2.0 control protocol will be a necessary step to more easily integrate with cloud- native CCAP Core systems and automated Operations Support Systems (OSS). The results include enablement of automation, acceleration of the network evolution, and significant reduction in the total cost of ownership for cable operators.

Why Cisco for Remote PHY?

Cisco's R-PHY solution is standards-based. Our Open-RPD software architecture was submitted to CableLabs® to become the basis for the new RPD industry standard. With Cisco R-PHY, you can mix and match standards-based RPDs from multiple vendors and deploy them as plug-and-play solutions in your nodes.

Lower CapEx

Our cBR-8 CCAP platforms are built from the ground up to capitalize on R-PHY. When you roll out R-PHY, you'll double the service groups each Cisco CMTS platform supports without adding any new hardware to the chassis.

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Support for existing DOCSIS network provisioning system

High-access bandwidth

Simple streamlined migration

With Cisco, you migrate your current cBR-8 CCAP platforms to R-PHY with a simple software upgrade.

Consolidated complexity, distributed simplicity

Our R-PHY devices are simple, low-touch/low maintenance devices to convert digital services for HFC. Complex functions are pushed back into the network, running on fewer platforms at fewer sites.

Fast and easy installation

Our comprehensive orchestration tool makes it easy for field technicians to install R-PHY. All the technician needs to do is scan a QR code, connect the device, and the orchestrator does the rest.

Benefits

The Cisco R-PHY solution provides a cost-effective digital fiber-based DOCSIS solution that uses Ethernet PON (EPON), Gigabit-capable Passive Optical Networks (GPON), or Metro Ethernet (MetroE) as the transmission network between the Cisco CMTS and CM. Both the PON technology and DOCSIS are used in the same network. Other benefits of Cisco's R-PHY solution include:

- Simple, low-cost PON transmission as opposed to costly HFC transformation
- Reduced investment cost including capital and operational expenditure
- Low-cost, yet highly stable Cisco GS7000 node (includes only the PHY layer)
- Reduced CMTS hardware complexity
- No restriction on Converged Interconnect Network (CIN) network
- Futureproof architecture that is easy to migrate as the hardware and control functions reside on separate layers
- End-to-end QoS assurance provided by DOCSIS
- Support for all DOCSIS services
- Support for existing DOCSIS network provisioning system
- High-access bandwidth

Learn More

For more information on Cisco Cable R-PHY and other solutions, please visit www.cisco.com/go/cable

For access to the full white paper prepared for SCTE-ISBE by Pawel Sowinski - Cisco Principal Engineer, Andy Smith - Cisco Principal Architect, and Tong Liu - Cisco Principal Engineer, please visit the NCTA Technical Paper site or go to https://nctatechnicalpapers.com/Paper/2019/2019-remote-phy-2-0-the-next-steps-for-remote-phy-technology

Conclusion

Remote-PHY 2.0 provides a valuable addition to the toolset available to operators as they continue to extend service offerings and provide ever-increasing bandwidth, while reducing capital and operational costs. The paper described many issues faced by the 1.0 version which may limit the utility of the R-PHY system going forward.▪ End-to-end QoS assurance provided by DOCSIS.