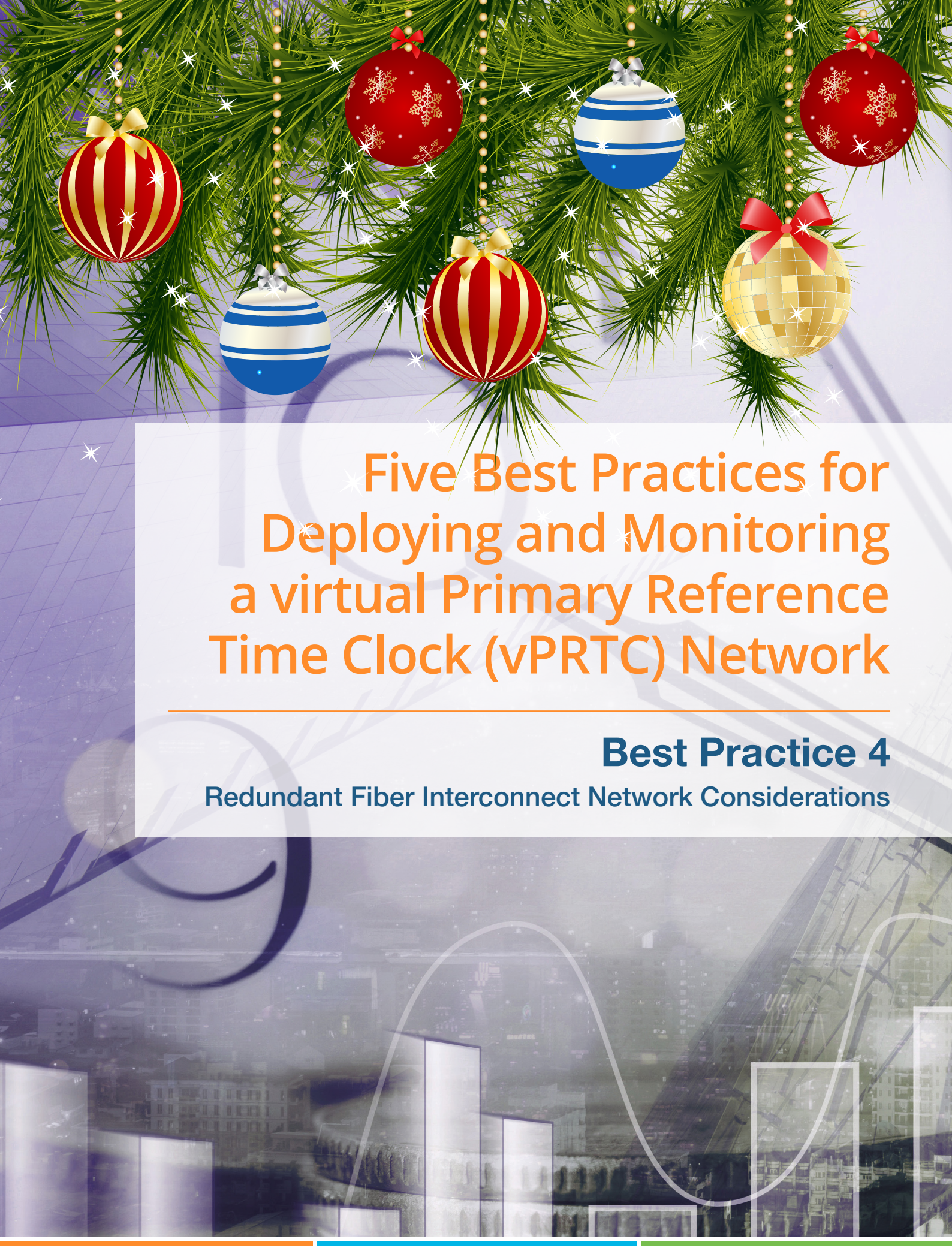


Five Best Practices for Deploying and Monitoring a virtual Primary Reference Time Clock (vPRTC) Network

Best Practice 4

Redundant Fiber Interconnect Network Considerations

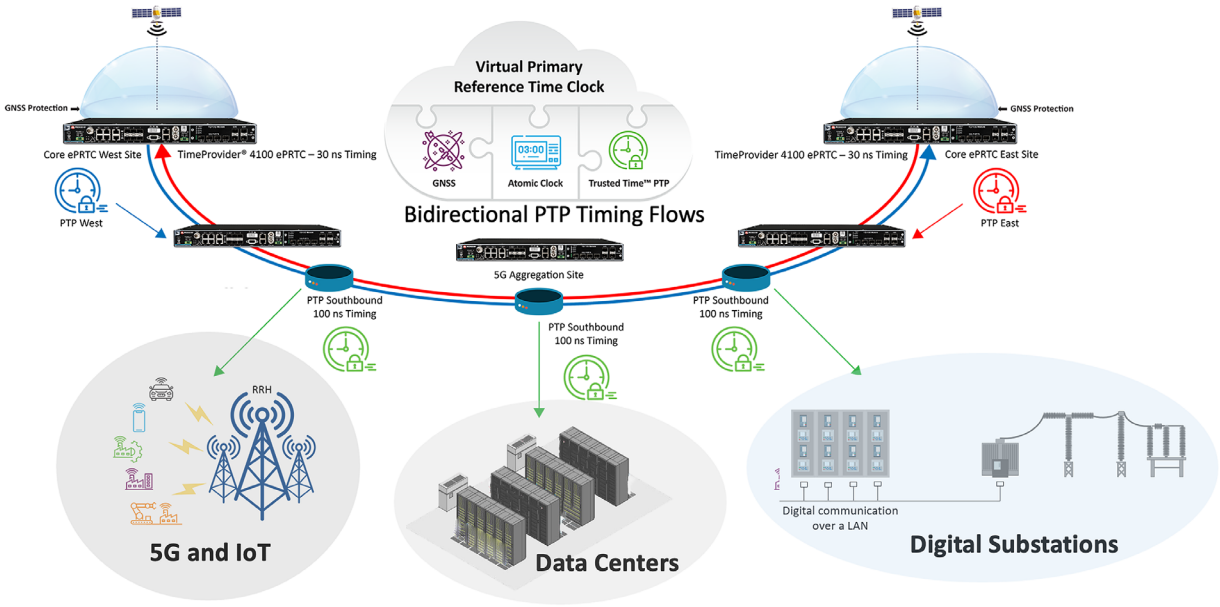
Five Best Practices for Deploying and Monitoring a virtual Primary Reference Time Clock (vPRTC) Network

Introduction

The virtual Primary Reference Time Clock (vPRTC) is a highly secure and resilient network-based timing architecture that has been developed to meet the expanding needs of modern critical infrastructures including 5G, transportation, data centers, and power utilities.

The resilient architecture alleviates dependency on satellite-based timing sources such as Global Navigation Satellite Systems (GNSS) by placing autonomous time scale grade atomic clocks in enhanced Primary Reference Time Clock (ePRTC) area timing-hub sites at the core of a fiber-based terrestrial timing distribution network. Secure core-timing sites and fiber distribution are 100% in control of the network operator, and immune to potential jamming or spoofing cyber-attacks on satellite-based timing solutions.

Figure 1. Virtual Primary Reference Time Clock Architecture Providing Resilient Timing for Critical Infrastructure Operators



This paper presents the fourth, out of five, key best-practices derived from millions of cumulative hours of operation of the vPRTC timing architecture accross multiple industries.

Best Practice 4: Redundant Fiber Interconnect Network Considerations

The optical transmission network for the vPRTC architecture is broken into two sections.

1. The core fiber interconnect for the connection between the ePRTC area timing hub sites and the east to west chain of TimeProvider 4100 HPBC clocks.
2. The southbound PTP distribution network from the individual TimeProvider HPBC clocks down to the end PTP client clocks in the operator's network.

There are many benefits to using dedicated timing paths with the vPRTC network. Not only do timing paths bring deterministic timing performance to the single-ns level, but also to the total separation of the traffic and the timing networks. This separation means any planned or unplanned updates or changes to the traffic network, such as firmware, line cards, or adding new equipment from existing or new vendor, cannot have any effect on the timing network.

The fiber interconnect for a resilient vPRTC east/west network using a single path design is made with one of the following three options:

1. DWDM using the Optical Timing Channel (OTC) or Optical Supervisory Channel (OSC)
    a. The OTCs often use SFPs at Fast Ethernet speed, which does allow for longer distances. It should be considered that Fast Ethernet timing channels prohibit the use of protocols like WhiteRabbit, which is why vPRTC is so widely deployed for timing over a wide area.
    b. OTCs will typically use an external filter, which means that the 2 lambdas used are very close to each other and in most cases reduce the static asymmetry to almost nothing.
2. Single fiber with bidirectional SFPs
    a. Commonly used for medium distances (approximately 100 km).
    b. Bidirectional SFPs have the advantage of using a single fiber, which saves money, but also means there are no problems with mismatched fiber pairs.
    c. The one drawback is to know the length of the fiber, so that the correct offset from the chromatic dispersion can be calculated.
3. Fiber pairs (least common)
    a. Using a pair of fibers can lead to issues; if the pair is not matched in length, any significant mismatch will create an offset.

The vPRTC timing architecture is very flexible and supports either the Optical Timing Channel (OTC) approach with a dedicated lambda, or the Optical Supervisory Channel (OSC) approach where timing is flowing with the management traffic. This flexibility allows the vPRTC architecture to operate with a wide range of optical vendor equipment and operator architectural timing transport preferences.

The southbound PTP timing distribution from the TimeProvider® 4100 HPBC sites is very flexible to suit the operator's end application PTP timing needs and transport options. The key benefit of the vPRTC architecture is that the TimeProvider® 4100 HPBC clock nodes all meet the PRTC-A 100 ns accuracy to UTC without depending on a local GNSS connection. The vPRTC is a much more resilient timing architecture with redundant paths back to operator-controlled area timing hub sites with cesium atomic frequency standard protected ePRTC systems. Table 1-4 shows best practices for southbound PTP distribution from the resilient TimeProvider® 4100 HPBC nodes.

Table 1-4. Best Practices for Southbound PTP Distribution from the Resilient TimeProvider® 4100 HPBC Nodes

Factor	Best Practice
PTP Profile	Configure the southbound PTP profile to support your end requirement needs (power, communications, and so on).
Redundancy	Assure that all PTP client clocks have access to a primary TimeProvider® 4100 Grandmaster as well as an alternate TimeProvider 4100 GrandMaster.
BMCA Switching	Configure PTP client devices to utilize the BMCA algorithm option for the PTP profile used to facilitate resilient switching if required.

Summary

Use the best and appropriate fiber path between the vPRTC nodes to ensure redundant delivery of timing from east and west directions as well as protected southbound PTP distribution to all end-application timing nodes.