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

Best Practice 1

Setting Up Your Resilient ePRTC Area Timing Hub Sites

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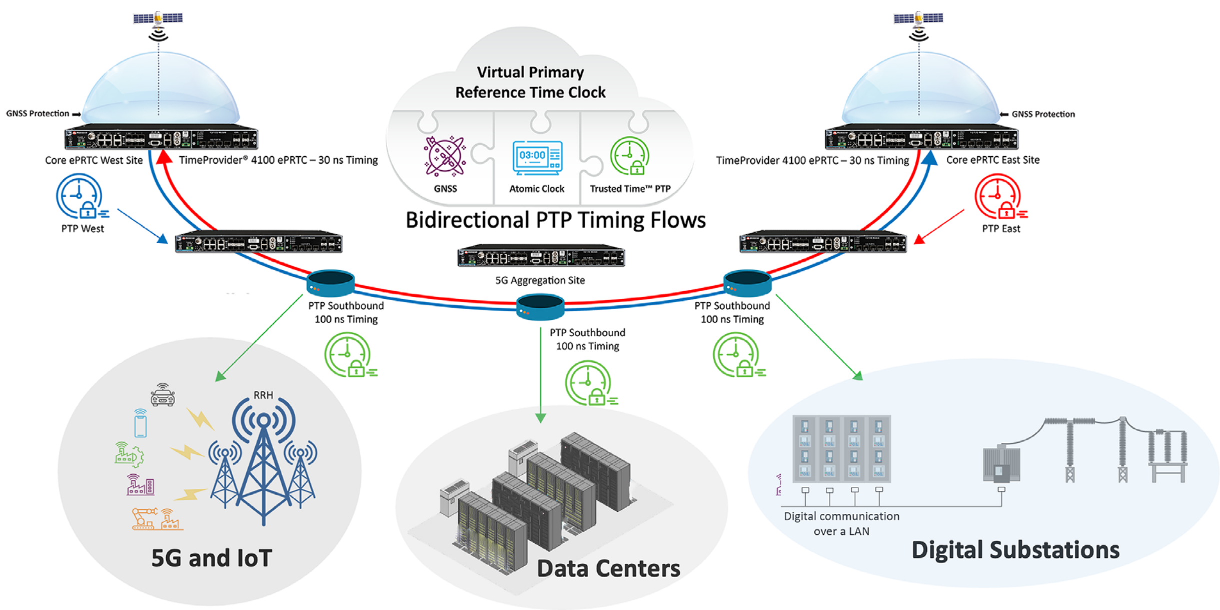
Introduction

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

Best Practice 1: Setting Up Your Resilient ePRTC Area Timing Hub Sites

The ePRTC performs two vital functions for any critical infrastructure network, the first being to provide a UTC reference of under 30 nanoseconds (ns) to the network with a stable frequency of 5.7 e-14, and the second being to offer a valid holdover source when GNSS is lost. When planning a network, 30 ns should be used for the error budget calculations; however, the actual performance of the TimeProvider® 4100 ePRTC units is much better, which allows the network a larger margin of error when deployed.

One bonus of the vPRTC timing network is the minimal number of sites that require GNSS. A typical network may only have three to five GNSS sites in total. The antenna installation has the biggest influence on the ePRTC accuracy and stability. The ePRTC can only be accurate to UTC when the antenna cable delay is known. Antenna cable delay varies depending on its material and construction. A typical delay for a cable is 3.9 ns per meter. When the ePRTC is trying to provide an accuracy of under 30 ns, a few meters can contribute error in the cable length and can destroy the hard-won accuracy.

When establishing your ePRTC sites, it's important to remember that there must be a minimum of two sites for network redundancy and protection. The ePRTC locations not only provide the accurate time for the entire networks, they also provide the backup in the event of GNSS jamming, spoofing, or failure. Table 1-2 is an ePRTC components list with descriptions on how to implement best practices.

Table 1-2. ePRTC Component List

ePRTC Components	Description
Calibrated GNSS Antenna Installation	It is vital to ensure that the GNSS antenna is accurately compensated for propagation delay through the cable length with elements such as lightning arresters, amplifiers, or splitters. Consult the TimeProvider® 4100 System User Guide for detailed instructions.
BlueSky™ GNSS Firewall	Recommended option for ePRTC installation to provide GNSS spoofing and jamming detection.
TimeProvider® 4100 PTP Grandmaster Server	When equipped with dual cesium clocks, there are two advantages. First, to protect the output performance of the ePRTC system. Second, dual cesium clocks further increase the performance and holdover ability of the ePRTC.
5071B Cesium Frequency Standard	Provides frequency and stability reference. It's best to have two cesium clocks at each ePRTC site, that way there is a backup to the critical infrastructure that's being established.
TimePictra® Software	Can view synchronization performance with end-to-end network visibility encompassing ePRTC systems at area timing hub locations and sub-tending aggregation and edge nodes.

With the importance of the ePRTC sites, installing the antenna properly requires careful planning, and any errors can cause the ePRTC to be inaccurate. The antenna location itself must be selected based solely on the ability to reliably receive the GNSS signal. It must be placed so that it has a clear view of as much sky as possible. Any obstructions such as antennas, large metal objects, or buildings limit the performance of the GNSS signal. This strict requirement for a GNSS antenna for any timing location means that it is very expensive, sometimes very difficult to use GNSS for time in an urban environment and further shows one of the huge benefits to bringing time to the city from a distant ePRTC area timing hub site.

When the ePRTC is first installed, it will provide a UTC reference, accurate to 30 ns or better within the first 48 hours. As the ePRTC characterizes the cesium frequency standard, the holdover performance will improve over time up to a maximum of 40 days.

Monitoring your ePRTC locations with the TimePictra® Synchronization Management System is vital to have a high level of confidence in your network, to know the event of a sustained GNSS outage, and that the network will continue to operate.

The ePRTC system includes sophisticated artificial intelligence algorithms to predict the level of performance based on measured stability and stabilization time. Figure 1-1 shows the holdover in days and protection availability monitoring graphs. The holdover meter provides a view of the number of days that the ePRTC system can maintain 100 ns traceability to UTC if the GNSS signal is lost. The protection availability meter shows that the system is fully stabilized and able to meet the ePRTC specification for holdover. The ePRTC standard specifies that the system must be able to hold 100 ns for 14 days after the required stabilization period. The system will provide 14 days of holdover after 14 days of stabilization and will maintain 100 ns holdover for 40 days after a 40-day stabilization period.

GNSS outages tend to be quite short, but at times they can last for several days. The protection availability gauge shows the percentage of holdover availability which is vital to know exactly how severely some GNSS outages have affected the network reserve. Figure 1-1 shows ePRTC holdover performance monitoring from the TimePictra Synchronization Management.

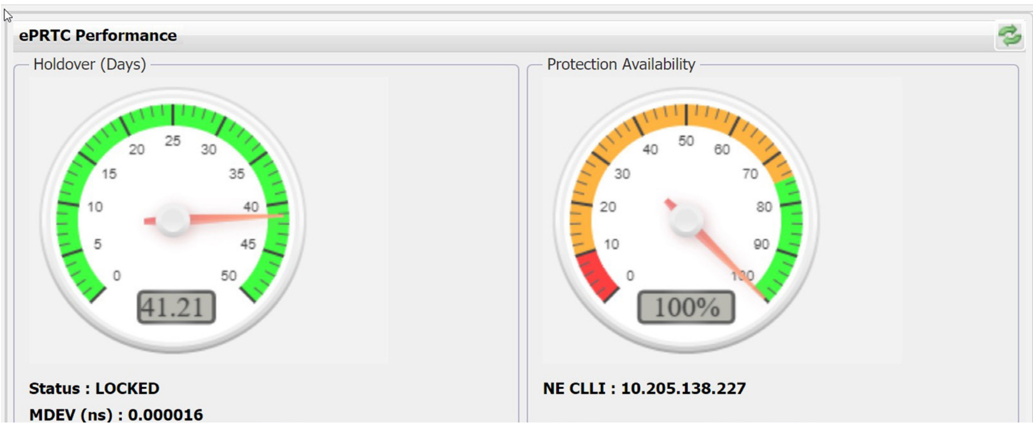


Figure 1-1. ePRTC Holdover Performance Monitoring from the TimePictra Synchronization Management System

The system is ready for 4.21 days of holdover protection to ±100 ns drift from UTC on the left, and 100% protection availability level on the right.

Summary

The vPRTC system allows chains of up to 15 hops where each hop can be about 150 km each, which allows for over 2000 km distance between ePRTC sites. The larger the distance between the ePRTC sites, the less chance of jamming and spoofing events affecting them both at the same time.