Time synchronization method in packet-switched transport network for mobile backhaul
draft-su-tictoc-time-sync-mode-01

Status of this Memo

This Internet-Draft is submitted to IETF in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF), its areas, and its working groups. Note that other groups may also distribute working documents as Internet-Drafts.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

The list of current Internet-Drafts can be accessed at http://www.ietf.org/ietf/1id-abstracts.txt.

The list of Internet-Draft Shadow Directories can be accessed at http://www.ietf.org/shadow.html.

This Internet-Draft will expire on October 10, 2009.

Copyright Notice

Copyright (c) 2009 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust’s Legal Provisions Relating to IETF Documents in effect on the date of publication of this document (http://trustee.ietf.org/license-info). Please review these documents carefully, as they describe your rights and restrictions with respect to this document.

Abstract

This document introduces a phase/time transfer application mode employing popular packet-based method IEEE Std 1588-2008 i.e. PTP
with support of common physical layer method Synchronous Ethernet in a packet-switched transport network for mobile backhaul and phase/time transfer protection switching.

Table of Contents

1. Introduction .................................................. 3
2. Conventions used in this document ......................... 3
3. Phase/time distribution in packet-switched transport network ........................................... 3
   3.1. Equipment type ........................................... 4
   3.2. Synchronous Ethernet support ............................. 4
   3.3. Building of phase/time synchronization path .......... 5
4. Phase/time distribution path switch ......................... 8
5. Security Considerations ......................................... 10
6. IANA Considerations ............................................ 10
7. Acknowledgments ................................................ 10
8. Informative References ......................................... 10
Authors’ Addresses ................................................. 11
1. Introduction

As the transport network for mobile backhaul has been migrated from circuit-switched technology to packet-switched technology such as Ethernet, IP/MPLS, packet-switched transport network is expected to provide timing and synchronization distribution function as SDH/SONET network does.

In 2G mobile backhaul network (e.g. GSM), only frequency synchronization is needed largely by locking base station clock onto a PRC traceable frequency source (i.e. E1/T1 links). By introduction of 3G cellular system (e.g. UMTS TDD, CDMA2000, TD-SCDMA, WiMAX), base stations need to be aligned each other in phase/time in order to guarantee smooth handover. 3G system with TDD mode stringently requires micro-second level phase/time synchronization. So currently the prevalent way to satisfy this requirement is that base station is synchronized to UTC time by installing GPS receiver on each of them. Due to the high cost and security issues, cellular operators are seeking solutions to replace or minimize the use of GPS and thus to distributes phase/time synchronization through transport network to base stations.

This I-D describes how to transport phase/time employing popular packet-based method IEEE Std 1588-2008 i.e. PTP with support of common physical layer method Synchronous Ethernet in a packet-switched transport network for mobile backhaul and considerations on phase/time transfer protection switching.

2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119.

3. Phase/time distribution in packet-switched transport network

The transport network in mobile backhaul between RNC and base station in general comprises aggregation part and access part. The RNC is connected to aggregation equipment (e.g. router or switch) which could be selected as time server or Grand Master (GM) in terms of PTP protocol. In this case, the equipment receives the UTC time by dedicated time interface (e.g. 1PPS + ToD) from GPS or BITS. The time server distributes time information by PTP interface to RNC and downstream equipment respectively. At the far end, access equipment outputs time signal to base station via dedicated time interface (e.g. 1PPS + ToD) or synchronizes the base station via PTP interface.
The later case requires that the base station support PTP protocol. The time distribution path from the GM to end equipment is logically a tree like topology.

3.1. Equipment type

There are basically two types of equipment in the time synchronization network, named PTP aware equipment and non-PTP aware equipment. PTP aware equipment includes standalone or integrated devices that implement Ordinary clock, Boundary clock, End-to-End transparent clock, Peer-to-Peer transparent clock or Management nodes. In this I-D, we focus on application of PTP equipment with Ordinary clock and Boundary clock. Other types of devices would be discussed in future. PTP equipment could enable BMC algorithm and each PTP port could be configured to use Delay Request-response measurement or Peer Delay measurement. Non-PTP equipment aware refers to switches or routers that deal with PTP packet as general data unit.

Normally, the number of nodes in aggregation network is much smaller than that in access network. So the employment of non-PTP equipment in aggregation network, in some respects, avoids the accumulated phase error induced by Boundary clock at cost of increasing the processing load of GM as well as introducing more PDV. In real network engineering, the PTP packet from GM may traverse some non-PTP equipments and is terminated by a Boundary clock at the demarcation point of aggregation network and access network.

3.2. Synchronous Ethernet support

PTP is based on the idea that master clock periodically adjust slave clock by calculating time difference between, compensated by transmission delay and node residence delay. So the frequency accuracy and stability of slave clock has considerable impact on the performance of PTP system. If the slave, for example, has local clock with frequency accuracy of 1ppm, the generated time offset rate will be 1us per second. This could be unacceptable for design and engineering of the network. In fact, the frequency accuracy of local clock has worse freerun or holdover performance than 1ppm in most of equipments particularly in access network. On the other hand, the better frequency accuracy makes the slave clock come into steady state as soon as possible, i.e. minimize the convergence time of the PTP. The less convergence time is also addressed by operators in case time source and/or time synchronization path protection switch occurs.

A possible way to enhance the performance under condition of low quality local clock is to increase the sync packet rate of master
clock in PTP, e.g. 100 or 1000 packet per second, but this would not be always effective if the congestion is introduced by intermediate non-PTP equipments. Obviously, the high rate of sync packet brings out more bandwidth consumption and spending of CPU resources.

Alternatively, the Synchronous Ethernet is a physical layer method that locks local clock to external stable frequency source or line timing signal from frequency synchronization network traceable to PRC. This provides an easy and reliable scheme for the time synchronization path to build the PTP operation on well-synchronized frequency distribution path. Each Boundary clock implements Synchronous Ethernet function including SSM detection and processing.

3.3. Building of phase/time synchronization path

The overview of time synchronization path construction is given by the flow chart in figure 1

Initially, a frequency synchronization path is formed on a link by link basis. The primary frequency source of the backhaul network could be the same source of time, e.g. given by GPS. In this case, all PTP equipments (with Ordinary clock or Boundary clock) hierarchically follow the frequency output of GM and a tree like frequency synchronization path is established from the GM to end equipments in the access network. The frequency source cloud be otherwise given from existing synchronization network and/or other external frequency source (e.g. BITS/SSU). The PTP equipment should perform clock source selection among multi frequency sources (e.g. recovered line timing from GE or 10GE Synchronous Ethernet links and/or external frequency source) by means of SSM detection or pre-configuration. It is noted that, the timing loop in frequency synchronization path should be prevented by network engineering or some enhanced automatic SSM mechanisms in order to avoid clock quality degradation.

After all nodes clock have entered into locked mode, each NE decides the PTP port state according to BMC algorithms.

In general case, the frequency reference source and the phase/time source are colocated in backhaul network. So the frequency distribution path and the phase/time distribution path could be congruent. Consequently, slave port of PTP BC could be simply selected as the port from which the timing signal is received and selected as reference frequency source. When multi phase/time sources exist and separate from frequency source, the BMC chooses the best master clock from set of priorities and thus logically selects the only PTP slave port.
Particularly, if the frequency reference source of the node is coming from any external clock (e.g. fed by BITS/SSU), the PTP slave port is decided by BMC.

If the node enters into holdover mode or before it locks/relocks to certain frequency reference source, time holdover steps in and PTP will neither change the port state nor receive and send sync packets until frequency stable state is recovered.

On the other hand, if a PTP port is not capable of recovering frequency from line timing, the port should syntonize the local clock by using receiving PTP message and complete phase/time alighment based on the tuned clock.
Figure 1
4. Phase/time distribution path switch

To show the relationship between time distribution path and frequency distribution path, and also the switch process of each, figure 2 and figure 3 are given below. In figure 2, PTP equipment A, B, C, D, E and F are interconnected by Synchronous Ethernet links in a ring topology. The time and frequency reference source of the network are co-located. The port I of each node is set to priority 1, the port II of each node is set to priority 2 in accordance with ITU-T G.781. Each node selects frequency reference source based on SSM code in QL-enabled mode as defined in ITU-T G.8264 and G.781. The frequency distribution path is indicated by flow arrows when all nodes are in locked mode. Port III of node A is configured as PTP slave port and port I and II are configured as PTP master port. Other nodes assign the PTP port state by above given rules. In this example, no PTP port is assigned as passive state. Finally, the time distribution path is formed congruent with frequency distribution path.

Figure 3 shows the case when the link between node E and node F is broken. Time distribution path stays unchanged but node E enters into time holdover and stop transmitting PTP message at master port. At the same time, node E sends SSM code DNU to inform node D to switch the frequency source. When node D finishes clock source switch, node E will follow line timing from port II of node D. At last, node D and node E re-entered into locked mode, thus a new frequency distribution path is built indicated by flow arrows. The PTP port state of node D and node E are consequently switched. Time transfer restores with the new time distribution path along rebuilt frequency distribution path.
Figure 2
5. Security Considerations

The time distribution given in this document may have security concerns as described in informative reference [TICTOC].

6. IANA Considerations

There have been no IANA considerations so far in this document.

7. Acknowledgments

It is appreciated that Mr. Su Hui, Mr. Yu Zhiyong and Mr. Shen Ruiwu have paid substantial work and contributions to this document.

8. Informative References

[1588] IEEE, "Standard for A Precision Clock Synchronization


Authors’ Addresses

Li He
ZTE Corporation
R.D. Building 3, ZTE Industrial Park, LiuXian Road
Shenzhen  518055
P.R.China

Email: he.li4@zte.com.cn

Fei Su
ZTE Corporation
R.D. Building 3, ZTE Industrial Park, LiuXian Road
Shenzhen  518055
P.R.China

Email: su.fei@zte.com.cn