Advanced NTP Synchronization Device for Internet Monitoring Tools

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Abstract

The latency is one of the important parameters for the Quality of Service (QoS) and it is measured at both ends of the network. This analysis is subject to the machine's clock and depends heavily on its precision. For the time synchronization among nodes, NTP (Network Time Protocol) [1] is used through the Internet, and the time accuracy is also very important at each NTP server.
In this research, we aimed to improve the time stability of the top NTP server (stratum1), and then we developed a server with higher stability, using the high precision frequency signal from the outside, instead of using the crystal oscillator on the motherboard of PC (Personal Computer). To input externally, we used the cesium atomic time (10^{-12}/day) and the high precision crystal oscillator (10^{-9}/day), but we found that the time stability of PC was at 1 microsecond order each, for the Linux time resolution.

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1. Introduction

Quality of Service (QoS) is one of the next-generation Internet technologies. And the latency is one of the important parameters of QoS. When the measuring the latency, all the measuring equipments must be synchronized for a regular number of days (for example, one month), for high quality of services. And the general method for its synchronization on the network is NTP (Network Time Protocol). Recently, for the electronic commerce, it has become more important to know an exact packet arrival time to a group of commerce servers to identify the first comer to serve and the time synchronization technology with high precision has also be requested. Currently, the time accuracy of stratum 1, based on GPS (Global Positioning System) is more than 10 microseconds. [2] (See the table 1, when the polling interval to GPS is 32 seconds at default). However, on a high-speed network such as OC-12, the transmission time of a packet with a typical size of 500 byte, is about 6 microseconds, and as a result, we must say that the time resolution of NTP server is not enough accurate now.
In this research, we aimed to improve the time accuracy of Linux OS of AT compatible machines for general purpose and used a high precision signal from the exterior to achieve it.

Table 1: Trimble Palisade receiver operating system compatibility

The Palisade driver has been tested on the following software and hardware platforms:

Platform	Operating System	NTP Sources	Accuracy
i386 (PC)	Linux	NTP Distribution	10 μ s
i386 (PC)	Windows 2000 and NT4.0 Server and Workstation	ftp://ftp.trimble.com/pub/ntp	1 ms
SUN	Solaris, Sun OS 4	NTP Distribution	50 μ s
Hewlett-Packard	HPUX 9,10,11	[illegible]	
Various	Free BSD	NTP Distribution	20 μ s
Cisco Routers	Models 7200	Cisco	20 μ s

http://www.trimble.com/oem/ntp/driver29.htm

2. NTP Server

NTP, which is widely used as a network time synchronization technology, constitutes the time synchronization system with a hierarchical structure. And this NTP acquires the UTC[1] (Coordinated Universal Time) at the top NTP server (stratum 1) from the external time sources. Recently, GPS has been used widely an external time source because of lower change of GPS receivers than before.
The smaller the polling interval to the external time source is, the better the time accuracy of Stratum 1 obtain. And when that interval is only 1 second, as precise as about 1 microsecond can be kept. (Refer to the table 1). However, when modifying the time, sometimes the time would be jumped or skipped. Therefore, we need to think another method and we suggest having better crystal oscillator inside the PC.

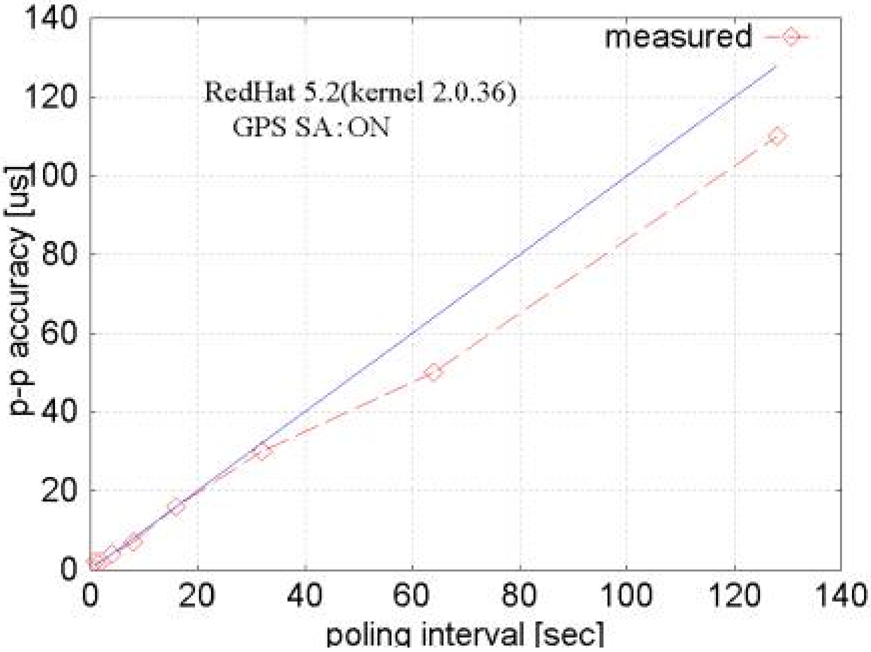

Figure 1: Accuracy vs. polling interval

3. Advanced NTP Synchronization Device

To replace the standard signal of 14.318MHz inside the PC, we developed an external signal inputting device which is PC-mountable. This device can convert the external 10MHz signal into 14.318MHz one, and as a time source, if only 10MHz signal can be generated, any sort of oscillators can be available.
Using this device, we measured the time stability when each signal of cesium atomic clock and the high precision crystal oscillator is used. The NTP server system constitution is shown in table 2. For the comparison of the time source, GPS is used with Palisade NTP of Trimble.

Table 2: The specification of our test system

OS	RedHat Linux 6.2 (Kernel 2.2.14)
Motherboard	Aopen AX6BC Pro
CPU	Pentium III 750MHz
Memory	128MB SDRAM PC/100 CL2
NTP distribution	ntp-4.0.99k
NTP reference	Trimble Palisade GPS Receiver
Polling interval	32 seconds (default value)

4. Cesium Atomic Clock

The cesium atomic clock controls and makes use of the cesium atom and it defines TAI[2] (International Atomic Time). This time, the clock is the one of HP5070A typed cesium atomic clock by Hewlett-Packard. This keeps the high precision with an accuracy of only less than 20 nanoseconds frequency stability (2.0 x 10^{-13}/day).
We measured the time difference between the NTP server and the one gained by the GPS reference. Loopstat, being attached to ntp-4.099, was used for this measurement. Table 2-2 shows its result, and as it shows, the standard deviation a day was found to be 0.55 microseconds. The time resolution of Linux, 1 microsecond, defines the NTP server time accuracy.

5. High Accuracy Crystal Oscillator

Next, we tried out a measurement, using a crystal oscillator that has lower precision but costs less than a cesium atomic clock. This oscillator, which is the universal time interval

counter by Standard Research System, keeps the accuracy of 10^{-9}/day.
As table 2-3 shows, we gained the result of 0.57 microseconds for the standard deviation less than 1 microsecond just as the secession 4. And then we conclude that there is no specific difference by the current Linux OS.

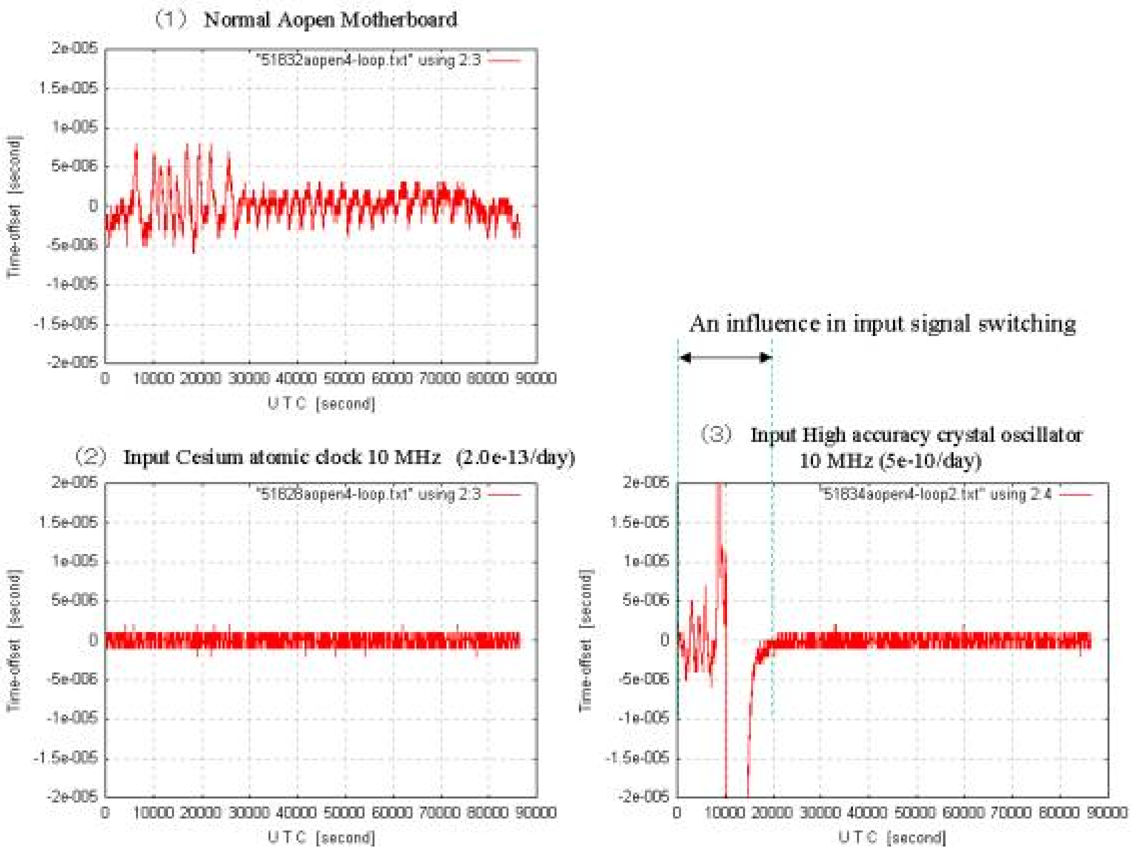

Figure 2: Time comparison between NTP server and GPS time

6. Conclusion

We developed a device to improve the precision of the standard frequency of 14.318 MHz inside the PC, using the external high stable signal. When the signal of the cesium atomic clock is input, the NTP server precision was found to be 0.55 microseconds as the standard deviation. Even when using the high stable crystal oscillator, we still gained 0.57 microseconds, so there is no any specific by the current Linux time resolution.
We need to improve the Linux time resolution for the NTP server of nanosecond precision for the future and this device will be necessary for the further network measurement.

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1 UTC: Since 1972, UTC is the atomic time made to approximate by "leap time adjustment" at the time of astronomy. The length for 1 second is the same as that of TAI.

2 TAI: Defines the time, in which the duration of 9,192,632,770 periods of the cesium 133 radiations as 1 second. This time has been measured successively since 1955.

Reference

1
D. L. Mills, "Network Time Protocol (Version 3)", RFC 1305, March 1992.

2
Trimble Palisade Receiver, URL http://www.trimble.com/oem/ntp/driver29.htm