Wei Zeng
Report of Project 4
12/03/2018

Report of Project 4

According to RFC 5905, the standard NTP packet, whose header is 48 bytes besides extension fields, key identifier and dgst, is a UDP datagram. The 48 bytes NTP packet header is shown in following figure.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|LI | VN  |Mode |    Stratum     |     Poll      |  Precision   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Root Delay                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Root Dispersion                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Reference ID                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                     Reference Timestamp (64)                  +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                      Origin Timestamp (64)                    +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                      Receive Timestamp (64)                   +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                      Transmit Timestamp (64)                  +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: 48 bytes NTP packet header

In the case of project 4, some variables in the standard NTP packet header need to be remained, however, some other variables need to be modified. Firstly, LI, VN and Mode can indicate the status of the NTP packet including warning of an impending leap second, version number and mode number, so NTP client/server can process NTP packets according to different status. Secondly, because all buoys will access to the same NTP server to synchronize the clocks and the server will not have the current system time, Stratum which indicates the stratum level of the local clock, Reference ID which identifies the reference source, Reference Timestamp which is the time that the local clock was last set or corrected, and Origin Timestamp which is the time that the request departed the client for the server should not be used in the NTP packet under this circumstance. Finally, the client needs to correct clock periodically and ensure the clock as accurate as possible, so Poll which indicates the maximum interval between two requests, Precision which indicates the precision of the local clock, Root Delay which indicates the total roundtrip delay to the primary reference source and Root Dispersion which indicates the nominal error relative to the primary reference source should be remained. Thus, the modified NTP packet header can be described as the fowling figure.

<table>
<tr><td>LI
2 bits</td><td>VN
3 bits</td><td>Mode
3 bits</td><td>None
1 byte</td><td>Poll
1 byte</td><td>Precision
1 byte</td></tr>
<tr><td colspan="6">Root Delay 4 bytes</td></tr>
<tr><td colspan="6">Root Dispersion 4 bytes</td></tr>
<tr><td colspan="6">None 4 bytes</td></tr>
<tr><td colspan="6">None 8 bytes</td></tr>
<tr><td colspan="6">None 8 bytes</td></tr>
<tr><td colspan="6">Receive Timestamp 8 bytes</td></tr>
<tr><td colspan="6">Transmit Timestamp 8 bytes</td></tr>
</table>

Figure 2: Modified NTP Request Packet Header

Because Receive Timestamp and Transmit Timestamp are used in the NTP response packet to show the processing delay (Transmit Timestamp – Receive Timestamp) and to help correct the client's clock, they should be remained. After sending a request, the client will record current system time t_2 immediately, then recording another system time t_4 when receive the NTP response. From the response, the client can also get the time t_1 that the server received the request and the time t_3 that the server sent the response. Thus, the client can calculate the offset of local clock by using offset = ((t1 – t2) + (t3 - 4)) / 2. If the absolute value of offset is less than 100, the local clock is synchronized; otherwise, the client needs to plus offset to correct its clock in small steps which is 100 in this case until the detected offset is less than 100.