Network Time Protocol

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ABSTRACT

Network Time Protocol (NTP) has been around for decades and is still the algorithm of choice for those people who want to keep computers within a network on the same time. There are different ways to implement NTP depending on the level of accuracy one needs for the applications using time. NTP creates a way to get the most precise atomic time to filter through networks to any computer. However, this does not mean that all computers are running off of exact atomic time. The best algorithms and atomic clocks cannot give the exact time forever. There must be corrections made to that time. There must also be corrections made further down the chain due to time delays caused by the connections between machines. Facing ever-changing obstacles and challenges, NTP constantly advances to give users the accurate value of time that they expect every day.

Keywords

Time Synchronization, NTP, SNTP, Network.

1. What is Network Time Protocol

As the frequency of computers across the world increased, it became clear that there needed to be a way to synchronize the times on each network and machine. In 1985, Network Time Protocol (NTP) was born. David Mills implemented what was to be known as NTP Version 0 that year in Fuzzball, while Louis Mamakos and Michael Petry implemented the protocol in UNIX at University of Maryland [4].

People have learned to find ways of communicating time with each other for as long as people have existed. Simply knowing one's age requires understanding of time and an agreement as to what scale to use. For the most part, the second is the most important measure of time: One can build a second into bigger measures of time as well as break it into the smallest units that are hard to imagine. Since 1967, the definition of the second has been defined as the duration of 9, 192, 631, 770 cycles of the radiation associated with a specified transition of the cesium atom [4]. There are three basic types of time. First, there is date and time-of-day. That is the type used for things like birthdays and anniversaries. Next, time intervals are how we compute things such as age. Lastly, there is frequency. Frequency is the rate of events occurring in a unit such as a second [4].

What does this have to do with NTP? In today's world, there are networks connecting everything from personal laptops to GPSs to cell phones to computer labs in universities. These networks need to be able to use an easily accessible value of time. NTP provides that service. As computers became faster through software and hardware advances, the need for a more precise value for time grew. Also, the need to synchronize that time across many networks became increasingly important. If two computers are connected and using data from each other with times that don't match, many problems could arise. Take, for example, data backup. If one computer saves all files from the other computer modified within the last five minutes, but the other computer has time that is slower than the first, then there could be files that are not saved and ultimately lost. This is a very real problem. This is just one example of why a way to transmit and synchronize time is so very important.

2. Implementation

There are different levels of accuracy when dealing with NTP. Those levels are called stratum. Atomic clocks, such as those that actually measure the radiation associated with the cesium atom as mentioned above for the value of a second, are the most accurate and, therefore, are stratum 0. That means that the other stratum levels down the chain use the calculation of lower levels to compute time for their respective clients. Clients can reference the calculated time from one or many different time servers. Servers in turn make their time available for any client to use [3]. In this way, time calculations can be sent and corrected many different times throughout networks. Having a hierarchical structure gives NTP a great deal of consistency and backups if something goes wrong on any individual machine, server, or clock. Stratum 0 devices, such as the clocks mentioned above, are the best time keepers. There are usually locally connected to Stratum 1 devices. This allows little time to be lost between Stratum 0 and 1. From here, networks connect Stratum 1 devices to Stratum 2 devices and Stratum 2 to Stratum 3 devises respectively.

At Tennessee Technological University (TTU), there is a Stratum 3 device to give time to computers on campus. There are different ways to access the time server. The following is one example of a script, written in Python, that gets the time from the TTU time server.

```
#!/usr/bin/python
from socket import *
import struct,time

time_server = ('time.tntech.edu', 123)

TIME1970 = 2208988800L

client = socket( AF_INET, SOCK_DGRAM )
data = '\x1b' + 47 * '\0'
client.sendto(data, time_server)
data, address = client.recvfrom( 1024 )
if data:
    print 'Response received from', address,'\n'
    t = struct.unpack( '!12I', data )[10]
    if t == 0:
        raise 'invalid response'
    ct = time.ctime(t - TIME1970)
    print 'Current time = %s\n' % ct
else:
    raise 'no data returned'
```

Even with the best algorithms currently known, it is impossible to exactly calculate time after a period of time. Thus, "leap seconds" need to be periodically added to the time of the clocks at stratum 0. When leap seconds are needed, the International Earth Rotation

Service announces them and adds the leap second on June 30 or December 31to the UTC time controlled by the National Institute of Standards and Technology. There are about 4 leap seconds added every 5 years [4]. While this is good for stratum 0, if a whole second can creep its way into stratum 0, there will be greater delays further down the hierarchy. Another way that NTP attempts to give correct times is by using the Marzullo algorithm. This particular algorithm takes various sources and efficiently estimates an accurate time. This algorithm was refined into the intersection algorithm used today. NTP combines that algorithm with many others such as combining, filtering, selection, and clustering algorithms to form a core group of algorithms. The combining algorithm simply gives an average of the time offsets of the best time sources found with the other algorithms. The filtering algorithm finds the best value of time from the many values obtained from an individual time server. The selection and clustering algorithms work together to pick the best time sources while discarding the bad sources [2]. All these algorithms work seamlessly together efficiently to provide a very accurate time for computers of all kinds to use.

If one does not need as accurate of a time, then the Simple Network Time Protocol (SNTP) could be used. SNTP simply uses the time value received from the time server it is connected to [2]. This protocol is obviously simpler and faster than NTP, but does not provide as accurate a value of time as NTP. If an application does not need accurate time, then this is the perfect protocol for that application. However, if an accurate time is needed, then that application should use NTP.

3. Conclusion

It is easy to see how important NTP is to computing in a modern world. With so many devices connected to each other through various networks, time synchronization and time accuracy are of the utmost importance. A network of computers simply cannot function without time management of some kind. Ever since it was developed, NTP has provided the best way to accomplish this task. From the most accurate atomic clocks to a simple home computer, NTP provides devices the correct value of time that those devices need to run well. NTP has evolved with the times to keep up with the advances in other areas of computing. The algorithms have allow the changes in hardware, such as faster connection speeds between devices, to affect the accuracy of the given value of time as little as possible.

4. REFERENCES

[1] David L. Mills. *A Brief History of NTP Time: Confessions of an Internet Timekeeper*. (Sept 2010) http://www.eecis.udel.edu/~mills/database/papers/history.pdf

[2] Hasan Bulut, Shrideep Pallickara, and Geoffrey Fox. *Implementing a NTP-Based Time Service within a Distributed Middleware System*. (Sept 2010) http://delivery.acm.org.ezproxy.tntech.edu/10.1145/1080000/1071589/p126-bulut.pdf?key1=1071589&key2=5956584821&coll=ACM&dl=ACMCFID=102368979&CFTOKEN=43721471

[3] Meinberg Funkuhren GmbH & Co. KG. *Network Time Protocol (NTP)*. (Sept 2010) http://www.meinberg.de/english/info/ntp.htm

[4] Michael A. Lombardi. *NIST Time and Frequency Services*. (Sept 2010) http://tf.nist.gov/general/pdf/1383.pdf