



NTP (Network Time Protocol)

Why it important for network measurement

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Network Performance Workshop

05-Apr-2006

- Used to synchronize a group of servers to UTC
 - Attempts to keep time monotonically increasing while minimizing offset and skew
 - These goals contradict
 - Stability vs Accuracy
- RFC 1305

- Caveats:

- Does not work very well for synchronizing to some (common) time
- Must be the correct time
- NTP does not deal with time zones (that's a time display problem)

Utility for Measurement

- Scheduling requires coarse grain agreement on time (lets start/end together)
 - Agreement must be “global” in scope - UTC
 - Individual servers communicate with multiple other hosts
- One-Way latency requirements
 - Jitter (requires stability of offset within sample)
 - Latency (requires accuracy)
- Sensible compromise
 - Well defined error representation

NTP Basics

- Each NTP node has a stratum
 - Stratum is an integer between 0 and 16, inclusively
 - Stratum 0 means a physical clock, never a computer
 - Cesium oscillator: definition of time (subject to relativistic effects)
 - Rubidium oscillator: found in cell towers, very stable
 - GPS receiver: accuracy circa 10 ns
 - CDMA receiver: accuracy circa 10 μ s

NTP Basics

- Each NTP node has a stratum (cont.)
 - Stratum 16 is reserved for devices that are not synchronized
 - The stratum of any NTP-synchronized device is the stratum of the device it is synchronized to plus 1, e.g.:
 - GPS receiver: stratum 0
 - Computer connected to it by a serial line: stratum 1
 - Client that gets the time from that computer: stratum 2

NTP Basics

- NTP servers form a loosely coupled network
 - Each node decides which server to use for synchronization based on complex selection algorithm (voting-like)
 - Selection algorithm run repeatedly for protection against falsetickers
 - Sanity checks
 - Error estimates
 - Resiliency to clock failure
 - Resiliency to network failure
 - Enforces the global nature of NTP

NTP Limitations

- Needs external servers to work well, even with a local clock
- Can produce systematic errors with asymmetric paths
- Can have problems with asymmetric congestion
- (And no time zones, remember?)

NTP and Temperature

- Oscillator frequency depends on temperature
 - Typical correspondence: 1PPM (part per million) of clock rate for 1 c
 - NTP can resolve rate differences of .001PPM
- For comparison: the temperature inside a modern computer will vary by 10 c depending on CPU load
- NTP could notice human movement around the host (!), and certainly open windows or A/C failures
- NTP will compensate, but best servers sit in constant-temperature machine rooms

Sensible NTPD policy

- Open firewalls and open querying
 - Let others know your notion of time
- Good error determination requires 4 clocks (4 peers)
- Resilient setups will attempt to have the paths to all peers be as divergent as possible
 - Asymmetric paths to peers will cause offsets

Sensible NTPD policy

- Only servers of stratum $n - 1$ (where n is my stratum) fully matter
- Important to select servers of the same strata in all cases
 - Use all stratum 1 peers for stratum 1 configurations (unless you can have multiple physical time sources)
 - Use all stratum 1 servers for stratum 2 configurations
 - Use all stratum 2 servers for stratum 3 configurations
 - But don't do stratum 3 configurations for measurement
- Do not mix strata

Sensible NTPD deployment

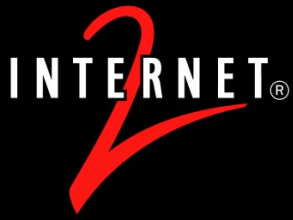
- Stratum 1 if you need maximum possible accuracy (single microseconds)
- Stratum 2 is suitable for machines that serve time to others or are used in measurements (accuracy can be better than 1ms)
- Stratum 3 is a reasonable end-user stratum
- Most measurement nodes will probably use NTP stratum 2
 - Best accuracy bang for the buck
 - OK accuracy for most needs
 - Can be set up on most machines with no new hardware

Sensible NTPD deployment

- Hardware/network requirements are minimal
- Minimize temperature variations to minimize clock wander
- Use “real” NTP - not OpenNTP or some MS thing
 - Linux/FreeBSD release distributions should be fine
 - BUT YOU MUST CONFIGURE IT (Redhat default config is BAD!)

Additional Resources

- <http://www.internet2.edu/%7Eshalunov/talks/20050322-Atlanta-PerformanceWorkshop-NTP.pdf>
- Man ntpd
- Man ntp.conf
- /usr/share/doc/ntp
- <http://e2epi.internet2.edu/owamp/details.html#NTP>
- Twiki.ntp.org/bin/view/Support/SelectingOffsiteNTPServers



Internet2 Sample NTPD Config

- <http://e2epi.internet2.edu/owamp/ntp/ntp.conf>

Verify NTPD

- Ntpq
- Ntpd statistics (log files)

Demo of clock querying

```
$ ntpq -p
```

```

remote          refid          st t when poll reach  delay  offset jitter
=====
+GPS_PALISADE(0) 0 l  5 16 377  0.000  2.377  0.800
oPPS(0)          .PPS.         0 l  6 16 377  0.000  2.466  0.854
-nms4-chin.abile .PPS.         1 u 47 64 377  4.151  3.485  6.883
-nms3-atla.abile .PPS.         1 u 54 64 377 11.272  3.878  6.571
-nms4-kscy.abile .PPS.         1 u 56 64 377  9.510  1.305  4.192
+caspak.cerias.p .GPS.         1 u 49 64 337  6.825  2.463  5.926

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