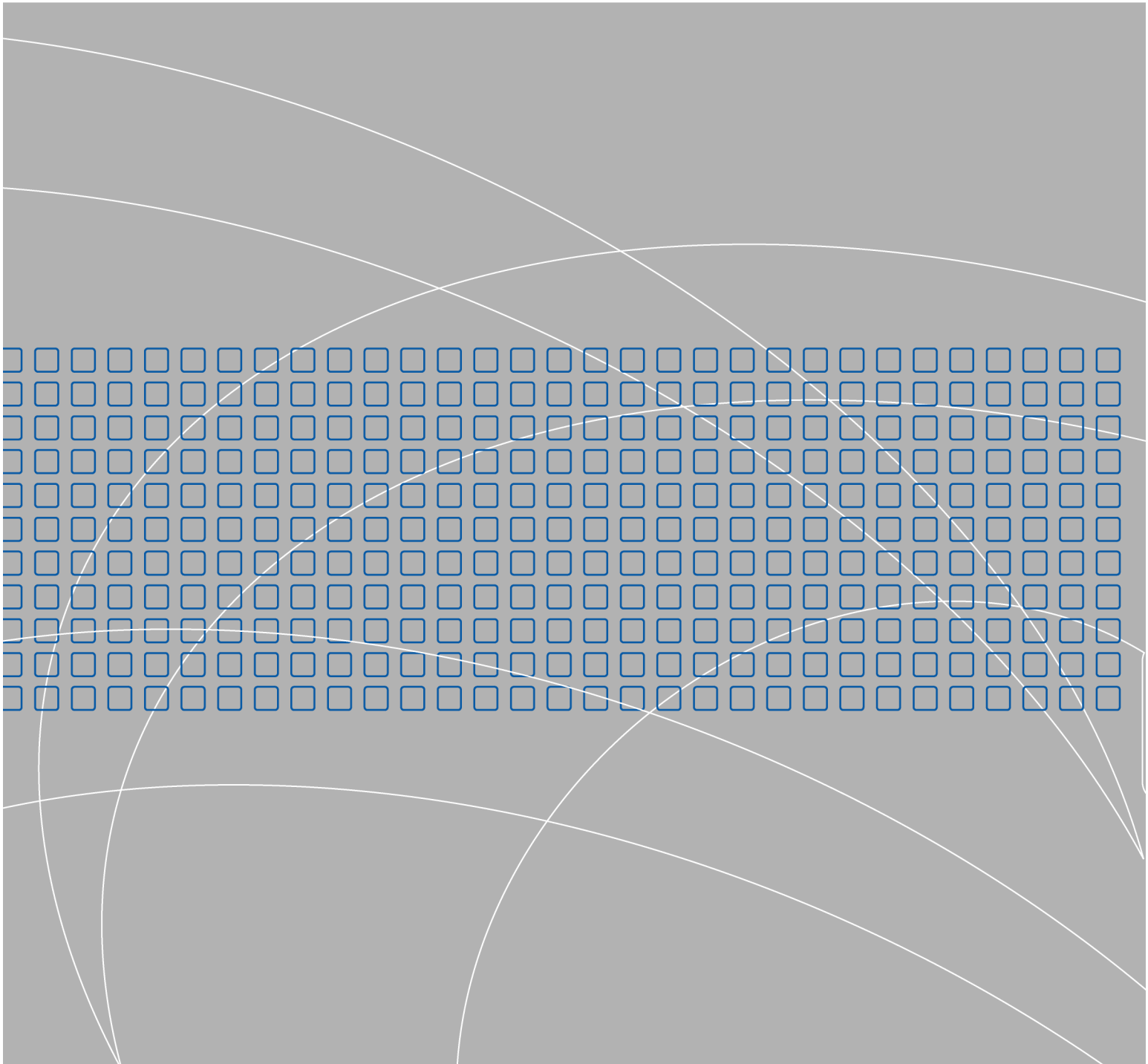
seeingmachines

Guide to using NTP with faceLAB™

30 November 2002



Guide to Using NTP with faceLAB™

Printed: November 2002 in Canberra, Australia

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1 What is NTP?

1.1 Overview

The *Network Time Protocol* (NTP) is an Internet protocol used to synchronize computer clocks. The protocol was first developed by Professor David L. Mills at the University of Delaware in 1988. Since then 4 versions of the protocol have been released.

1.2 How does it work?

Universal Time Coordinated

NTP does not synchronize computers directly to each other, but instead synchronizes each computer independently to the world's official time standard, Universal Time Coordinated (UTC). This is a world-wide time reference independent of time zones (i.e. "universal"), and is determined from a combination of time estimates from several institutions around the world (i.e. "coordinated") [Windl et.al, 2002].

Time Servers

UTC is best measured using high precision devices such as atomic clocks. Due to their prohibitive cost, it is not possible for every computer to have such a device. But it is possible for a handful of machines to have such clocks. These computers can then act as a time reference server to other computers who wish to be synchronized to UTC. These machines can then in turn act as servers to other computers. Of course, this requires the round trip delay for every network connection to be taken into account.

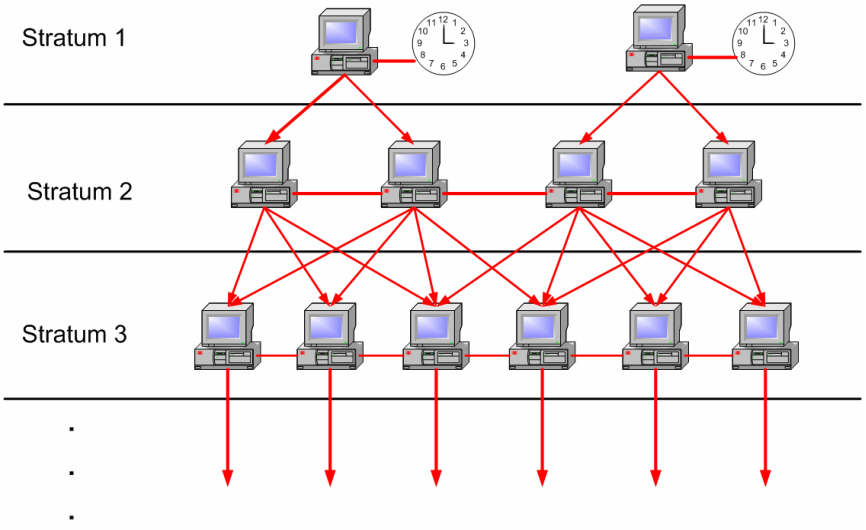

Figure 1- NTP time reference hierarchy

This is the basis of NTP's time reference hierarchy, shown in Figure 1. Each level in the hierarchy is known as a "stratum". In general, the lower the stratum number, the more accurate a reference server is considered to be. In Figure 1, the most accurate reference servers at Stratum 1 are shown at the top of the diagram.

1.3 Accuracy

NTP synchronizes one computer to another by communicating through a network connection. The accuracy of the synchronization is therefore limited by the quality of the network environment, i.e. computers linked with a high quality network connection with moderate traffic will synchronize with better accuracy than those with poor connections.

Accuracy Requirement for faceLAB™

The achievable synchronization accuracy quoted in the NTP literature varies from microseconds to seconds. faceLAB™ requires a minimum synchronization accuracy of 0.01667 seconds (16.67 milliseconds). This is determined by the fact that faceLAB™ processes 60 video frames per second (i.e. 1 second / 60 frames = 0.01667s).

1.4 How long does NTP take to Synchronize?

An NTP client can take up to an hour stabilize when first connected to a server. When a client connects to a server, the first time adjustment won't occur for five to fifteen minutes. The time difference will improve over the next 24 hours until reasonably stable [1]. [Dalton,1997].

Figure 2 plots the time difference, or offset, between a typical client and server connected on a 100 Mbps LAN. Both client and server were restarted immediately before the plot origin. It is seen the client took approximately 50 minutes before satisfying this requirement.

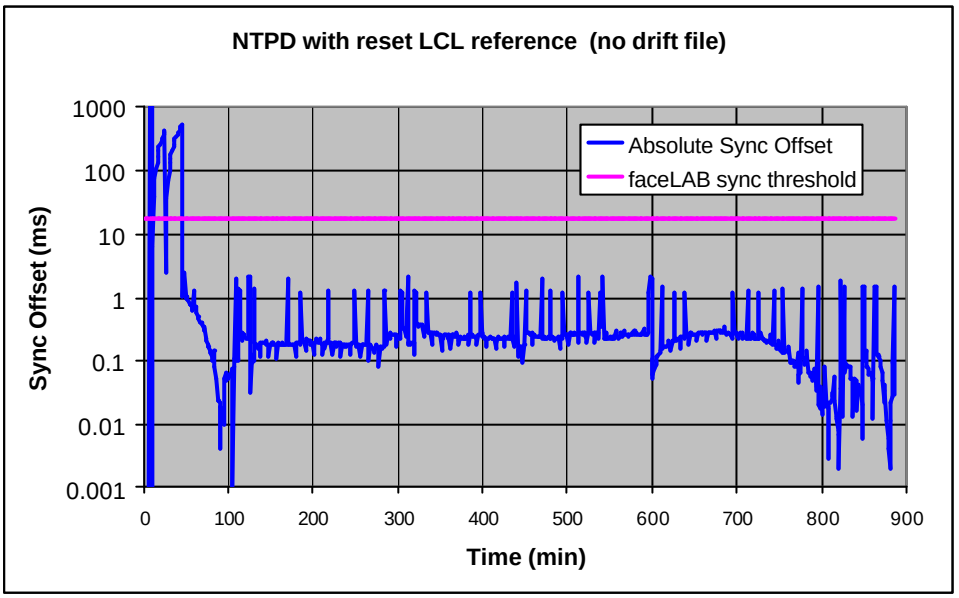

Figure 2 – Synchronization Stabilization for a typical client connected to a NTP server.

1.5 NTP Network Configurations for faceLAB™

NTP can be configured to support many different network configurations. This section outlines those configurations relevant for use with faceLAB™.

Single Server, Multiple Clients

You may have two or more computers on your network you wish to synchronize. Only one of these should act as a server, with all other machines connecting to this server as clients, as seen in Figure 3.

[1] The NTP implementation discussed in the Section 2 offers the ability to significantly reduce the time taken to synchronize.

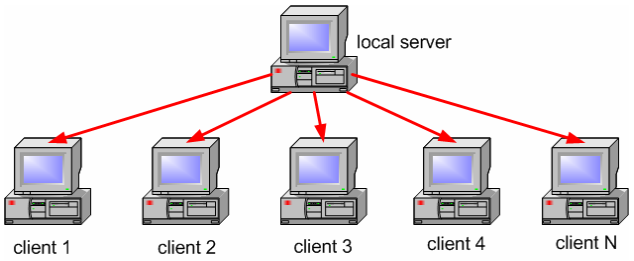

Figure 3 - Clients connected to a single server

Choosing a Server

Any computer, including the faceLAB™ machine, can act as the designated server. It is preferable to choose a computer with a reliable clock.

Disciplined Server

The accuracy of your chosen server can be improved if it references time servers of a lower stratum number, on an external network, as shown in Figure 4.

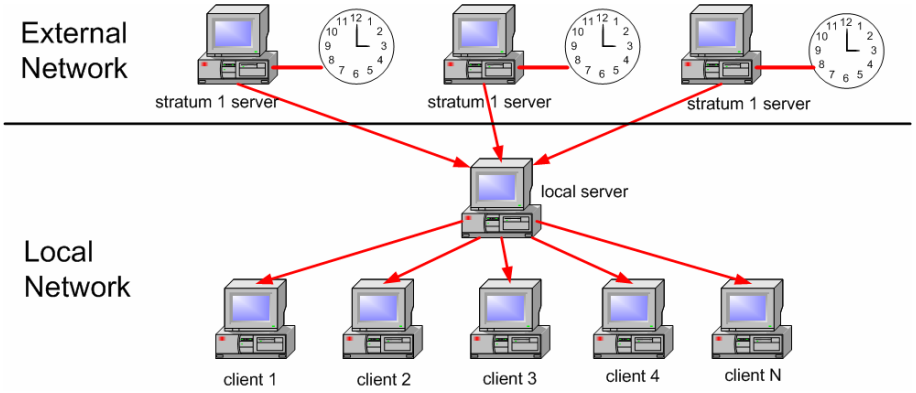

Figure 4 – Clients connected to a server disciplined by other servers.

Note that only the local server, not the clients, connect to the external time servers. This is important for minimizing configuration maintenance: if the external time servers must be changed, then only the configuration of your local server need change, but not the clients.

It is considered important to discipline your local server with at least 3 external servers, preferably more. This is to improve robustness through redundancy, and to safeguard against incorrect servers[2].

Each external server should be as close as possible to your geographic location, to minimize network delays which can compromise synchronization accuracy [Dalton,1997].

Undisciplined Server

Often the computers you wish to synchronize must operate in isolation from external networks, and therefore your local server cannot use lower stratum time servers. In this situation the local clock of your local server can be made the UTC reference. The server's clock is therefore considered "undisciplined", i.e. it has no reference and may drift without correction. Clients can still synchronize to the local server, but all the synchronize clocks will drift together with the local server.

[2] A surprising number of stratum 1 servers hold incorrect time. A 1999 study found that more than 30% of stratum-1 servers had a clock error of more than 10 seconds [Minor,1999].

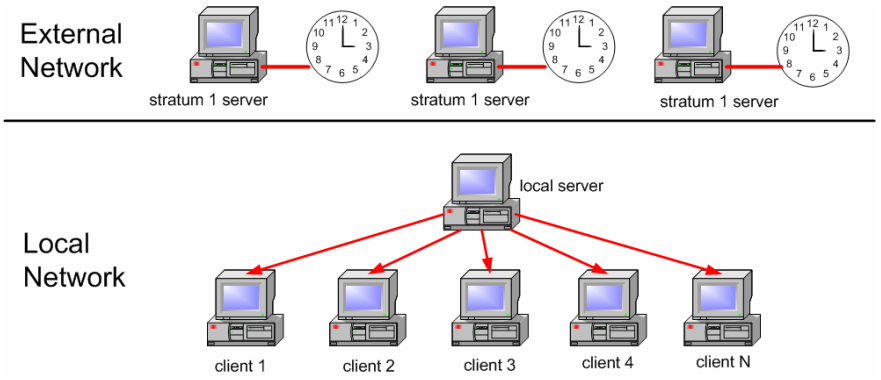

Figure 5 – Clients connected to an undisciplined server that does not reference time from other servers.

Note: Care must be taken when using an undisciplined server. If the server is connected to the Internet, it may confuse unsuspecting clients on external networks who won't realize the server is not a true UTC reference. At the very least, an undisciplined server should indicate to clients it is undisciplined. [Windl,2002]. How to do this is explained in Section 5.3.

2 NTP FastTrack

2.1 What is NTP FastTrack?

The originators of NTP implemented a freeware software implementation of the protocol, known as the "NTP Distribution". The distribution supports Linux/Unix, Windows and many other platforms, with full source code and documentation provided for both. The distribution includes:

- an NTP service for synchronizing your machine;
- a variety of tools for monitoring synchronization;
- scripts for retrospective analysis of synchronization accuracy;
- extensive (and at first overwhelming) documentation.

For the convenience of faceLAB™ customers, Seeing Machines distributes a simplified adaptation of the NTP Distribution, known as **NTP FastTrack**, intended for Linux/Windows users, including:

- NTP binaries for Windows (thus removing the need for customers to build the source code);
- Windows installer script
- Source files for compilation in Linux or Windows
- A script for fast tracking the installation of the NTP service in Linux;
- This document.

2.2 Where can I get it?

NTP FastTrack 1.0 can be downloaded from:

- **Windows Users:**
  http://ftp.seeingmachines.com/pub/facelab/tools/NTP/NTP_FastTrack_1.0.0_win_install.exe

- **Linux Users:**
  http://ftp.seeingmachines.com/pub/facelab/tools/NTP/NTP_FastTrack_1.0.0.tar.gz

The full NTP distribution can be downloaded from:

www.ntp.org

2.3 ntpd – The NTP Service

The core component of the NTP distribution is the NTP service, called *ntpd* (NTP-daemon). This application runs as a background process[3] on every machine you wish to synchronize, and can operate as a client, a server, or both.

When *ntpd* is started, it reads a configuration file called ntp.conf. Section 5 explains how this file can be edited to configure *ntpd* for your purposes.

2.4 ntpq – A Tool for Monitoring Synchronization

ntpq (NTP-query) is a command line program used to query NTP servers. It is most commonly used to query the time difference between a client and specified servers. This is important for verifying your computers are adequately synchronized.

[3] Known as a "service" in Windows, or "daemon" in Unix/Linux

3 Running a NTP service on Windows

This section outlines how to install, stop and start an NTP service (*ntpd*) in Windows 2000 and Windows XP. The configuration of an NTP service is deferred until Section 5.

3.1 Installing NTP FastTrack

To install NTP FastTrack:

1. Open NTP_FastTrack_1.0.0_win_install.exe;
2. Follow the Installer instructions;
3. Shortcuts to the components of NTP FastTrack 1.0 are added to Start Menu. To view them, click **Start**, click **Programs**, click **Seeing Machines**, click **NTP FastTrack 1.0**.

3.2 Disabling the Windows Time Service

Windows 2000 and Windows XP both come with a pre-installed NTP service, called "Windows Time". According to Microsoft this only provides "loose synchronization", and should only be used by applications "that do not require the degree of accuracy that NTP provides" [Brandolini et.al, 2001].

Windows Time must be disabled when using *ntpd*, otherwise it will interfere with the *ntpd* service. To stop and disable Windows Time:

1. Click **Start**, click **Programs**, click **Seeing Machines**, click **NTP FastTrack 1.0**, click **ntpd**, click **Starting and Stopping**, click **Shortcut to Services**. This opens the Services management console.
2. Double click the **Windows Time** service in the **Services** list. A properties window appears.
3. Click the **Stop** button.
4. Select the **Disabled** item in the **Startup type** dropdown combo box, as shown in Figure 6.

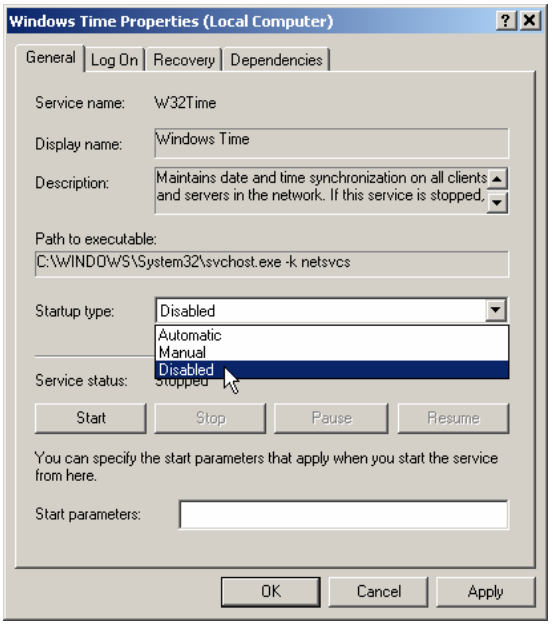

Figure 6 – Stopping and Disabling the Windows Time Service

3.3 Installing the NTP Windows service

To install *ntpd* as a Windows Service:

1. Click **Start**, click **Programs**, click **Seeing Machines**, click **NTP FastTrack 1.0**, click **ntpd**, click **Service Installation**, click **Install**.

As illustrated in Figure 7, a command prompt will appear, with a message saying the service was "successfully created". (The remainder of the message can safely be ignored.)

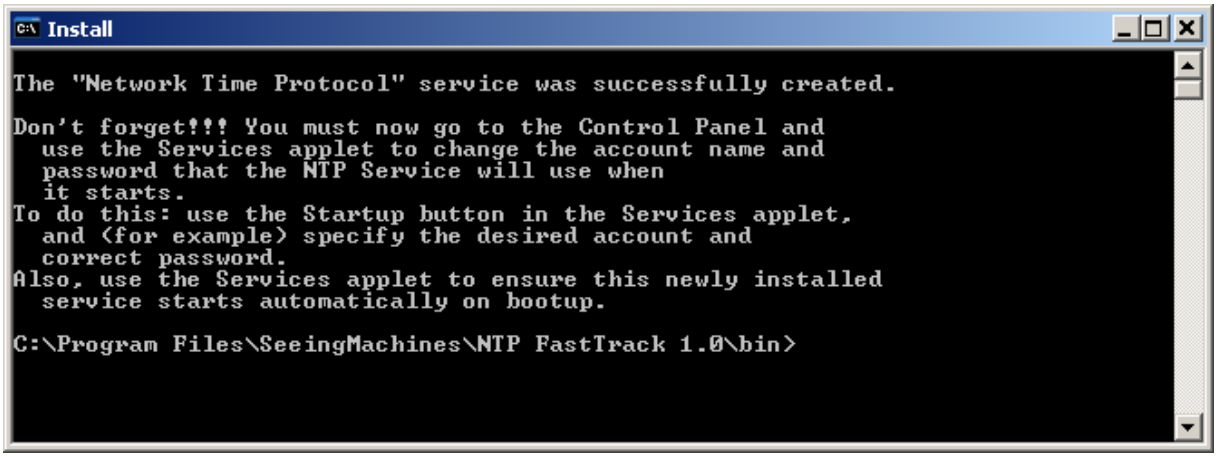

Figure 7 – Installing the ntpd Service from the command line

To uninstall *ntpd*:

1. Click **Start**, click **Programs**, click **Seeing Machines**, click **NTP FastTrack 1.0,** click **ntpd**, click **Service Installation**, click **Remove**.

Note that *ntpd* must be stopped (see Section 3.4) for uninstallation to work.

3.4 Starting and Stopping the NTP service

Once *ntpd* has been installed as a service, it can be started and stopped from the Services management console.

Starting

1. Click **Start**, click **Programs**, click **Seeing Machines**, click **NTP FastTrack 1.0**, click **ntpd**, click **Starting and Stopping**, click **Shortcut to Services**. This opens the Services management console.
2. Right click the **Network Time Protocol** item in the **Services** list (this is the *ntpd* service). A context menu appears (as shown in Figure 8).
3. Click **Start.**

Stopping

In the Services list, highlight the service labelled **Network Time Protocol**, and select the **Stop** button.

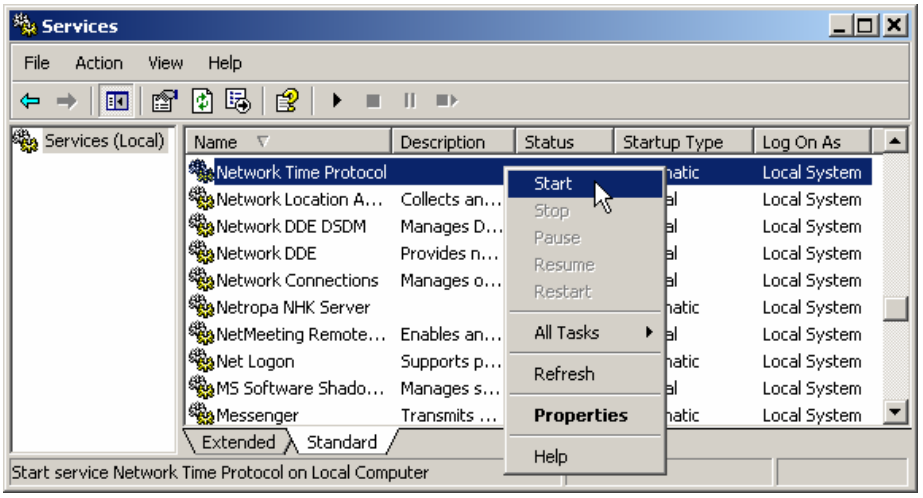

Figure 8 – Starting the ntpd service

Automatic Startup

It is convenient to have the *ntpd* service automatically restart when you restart your computer. In the Services management console:

1. Right click the **Network Time Protocol** item in the **Services** list. A context menu appears (as shown in Figure 8).
2. Click Properties.
3. Select the **Automatic** item in the **Startup type** dropdown combo box.

3.5 Viewing the NTP Log

ntpd periodically logs its major events, such as starting, stopping, plus any clock synchronization updates. This log information can be viewed using the Windows "Event Viewer" management console:

1. Click **Start**, click **Programs**, click **Seeing Machines**, click **NTP FastTrack 1.0**, click **ntpd**, click **Starting and Stopping**, click **Shortcut to Event Viewer**. This opens the Event Viewer management console.
2. Double click the **Application** icon. A list of events appears.
3. Click the **Date** column to order the events chronologically.
4. Right click an event, select **Properties** in the context menu (as shown in Figure 9). This opens a properties window containing an explanation of the event.

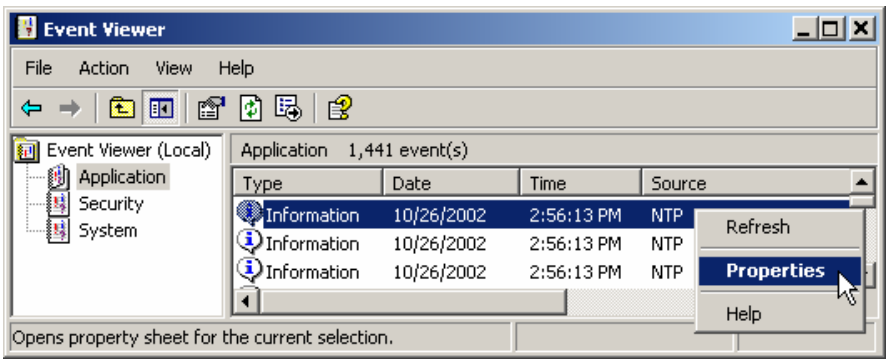

Figure 9 – Viewing the ntpd event log

The Event Viewer does not refresh its display very often. For the latest NTP events to be visible, you may sometimes have to force a refresh using the F5 button.

Log Entries for Stopping and Starting ntpd

The following three event log entries should appear once you start the *ntpd* service:

- "ntpd 4.1.1a Tue Oct 15 10:31:00 2002 (2)" - or something similar;
- "precision = 7 usec" - the actual number will vary;

When stopping the *ntpd* service, the following log entry should appear in the event viewer.

- The Network Time Protocol Service has stopped.

3.6 Overriding the 1000 second Sanity Limit

ntpd automatically exits if the synchronization offset between itself and its designated server exceeds 1000 seconds (~16.6 minutes) [Mills, 2002, ntpd]. This may be a problem when first synchronizing computers that initially have a large offset.

It is possible to override this sanity limit by editing the Registry using the Registry Editor.

WARNING: Using Registry Editor incorrectly can cause serious problems that may require you to reinstall your operating system. Seeing Machines cannot guarantee that problems resulting from the incorrect use of Registry Editor can be solved. Use Registry Editor at your own risk.

1. Click **Start**, click **Run**. This opens the **Run** dialog.
2. Type **regedit.exe**, then click **OK**. The **Registry Editor** window launches.
3. In the key hierarchy shown in the left of the Registry Editor, click **HKEY_LOCAL_MACHINE**, click **SYSTEM**, click **CurrentControlSet**, click **Service**, click **NTP**. In the right hand side of the window, a list of keys is shown, as illustrated in Figure 10.
4. Double click the **ImagePath** key. An **Edit String** dialog appears. The **Value data** text edit contains the path of ntpd.exe.
5. At the end of the path, type ' –g', as shown in Figure 10, then click **OK**.
6. Exit the Registry Editor.

Note that *ntpd* must be restarted (see Section 3.4) before this will take effect.

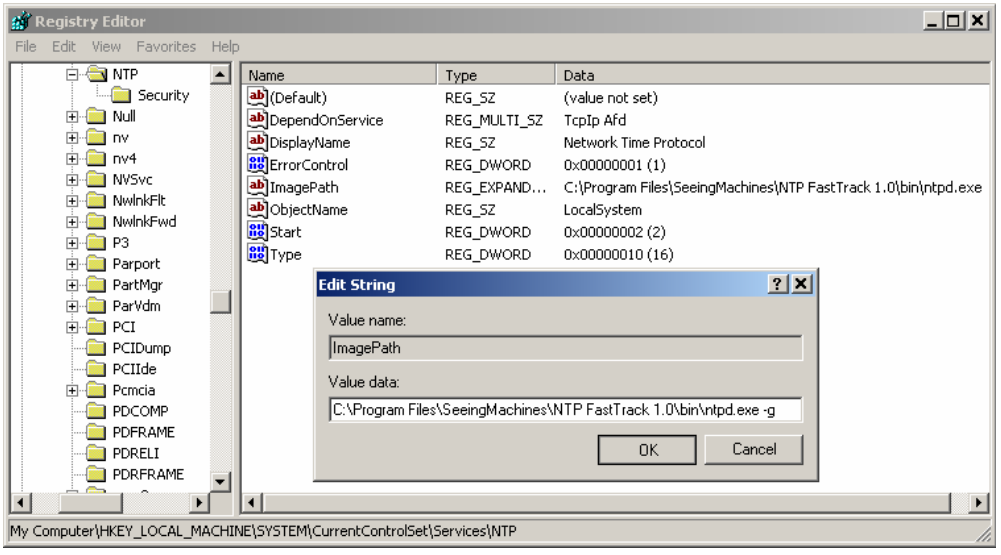

Figure 10 – Editing the registry to override the 1000 second sanity limit

4 Running an NTP service on Linux

This section outlines how to install, stop and start a NTP service (*ntpd*) in Linux. The configuration of *ntpd* is deferred until Section 5.

Since there are many different Linux varieties, some assumptions have been made about file locations. You may need to adapt some of these instructions to suit your local Linux configuration.

4.1 Check for pre-installed NTP daemons

First, check to see if you have any NTP daemons running:

- `ps -ef | grep ntpd`

If *ntpd* or *xntpd* are listed, aside from in the grep command, you will have to manually configure the daemon. We also recommend that you make sure the NTP daemon is at least 4.1. You can do this by examining /var/log/syslog when the daemon is started.

4.2 Installation

Linux installation requires building the binaries from source code. The build uses standard tools including GCC, Perl and make, which should be included in your Linux distribution. You will need root permissions to install and run an NTP daemon since it updates the system time. To build and install the NTP distribution:

1. Open a terminal as the 'root' user.
2. 'cd' to the directory containing the file NTP_FastTrack_1.0.0.tar.gz.
3. Unzip the tarred/zipped file using 'tar xzvf NTP_FastTrack_1.0.0.tar.gz'
4. Change into the distribution directory using 'cd NTP_FastTrack_1.0.0'
5. Unzip the tarred/zipped NTP distribution using 'tar xzvf ntp-4.1.1a.tar.gz'
6. Change into the NTP distribution directory using 'cd ntp-4.1.1a'
7. Type './configure' to configure the package for your system. The script will take a while to complete, and will prints some messages telling which features it is checking for.
8. Type 'make' to compile the package.
9. Type 'make check' to run some scripts which will test the installation.
10. Type 'make install'.
11. Change back into the Seeing Machines distribution directory using 'cd ..'
12. Run a script to install the daemon and run on startup using './sm_install.pl'.

This will install the NTP distribution binaries into /usr/local/bin, and start the ntpd daemon[4]. It will also ensure the daemon restarts when you reboot your computer.

If you wish to remove the daemon from startup, run the sm_uninstall.pl script in the NTP_FastTrack_1.0.0 directory.

For optional instructions on building/installing, or if warnings or errors occurred while following these instructions, please refer to the INSTALL file included with the NTP distribution.

[4] *ntpd* is started with the '-g' argument to override the 1000 second sanity limit (see Section 3.6).

4.3 Starting and Stopping the NTP service

Starting

To start the NTP service:

1. 'cd' to the directory containing the binaries - /usr/local/bin.
2. Type 'ntpd -g'
3. *ntpd* will attempt to read the configuration file ntp.conf from /etc. To specify an alternative ntp.conf file, start ntpd by typing 'ntpd –g –c <ntp.conf file path>'.

Stopping

To stop the service, you must kill the *ntpd* process.

5 Configuring your NTP Service

Your *ntpd* service can be configured by editing a configuration file, called ntp.conf. This allows you to specify:

- whether your service is a client, server, or both;
- what server a client will use;
- whether a server is "disciplined" or "undisciplined";
- if the service should log clock drift information, to reduce synchronization time in the future;
- How often a client queries a server.

Note: it is important to realize that changes do the configuration file will not take effect until you restart the service.

5.1 Location of ntp.conf

ntpd expects the ntp.conf configuration file to be in a specific directory. This directory is different for each operating system, as shown in Table 1. (For Windows users, a shortcut to ntp.conf is provided in the **NTP FastTrack 1.0** Programs menu.)

Windows 2000	C:\WINNT\SYSTEM32\DRIVERS\ETC
Windows XP	C:\WINDOWS\SYSTEM32\DRIVERS\ETC
Linux	/etc

Table 1 – The expected path for ntp.conf for each platform

5.2 Configuring an Externally Disciplined Server

As explained in Section 1.5 your local time server can itself by synchronized to more accurate time servers. Using this configuration requires specifying the IP address of each server in the ntp.conf file, as shown below. (Note that the first two lines starting with a '#' character contain comments that do not affect the ntpd configuration).

```
# ntp.conf
# Externally Disciplined Server

server ntp.nml.csiro.au
server ntp.per.nml.csiro.au
server ntp.adelaide.edu.au
server ntp.mel.nml.csiro.au
```

An example ntp.conf for a server with external time references.

Note that, as recommended in Section 1.5, at least 3 external servers have been specified. A list of stratum 1 and stratum 2 servers can be found at:

http://www.eecis.udel.edu/~mills/ntp/servers.html

5.3 Configuring an Undisciplined Server

To configure your *ntpd* service as an "undisciplined" server (see Section 1.5) place the following lines in your ntp.conf file:

```
# ntp.conf
# Undisciplined Server

server 127.127.1.1                # Specify server is undisciplined
fudge  127.127.1.1 stratum 10     # Server has low stratum to reflect possible drift
```

ntp.conf for a server with an undisciplined local clock

The server name 127.127.1.1 is a pseudo-IP address that specifies to use an undisciplined server.

Note that the stratum of the server is manually set as a low stratum, to indicate to unsuspecting clients that it is not a high accuracy server.

5.4 Configuring a Client

If you wish your *ntpd* service to be a client, your ntp.conf file only needs to specify the IP address of your server.

```
# ntp.conf
# Client connected to a single server

server 10.10.10.242         # specify the IP address of the client's time server
```

An example ntp.conf for a client connecting to server with IP address 10.10.10.242

Note that there is nothing in this configuration restricting your client from being used as a server. However, as outlined in Section 1.5, only one machine in your local network should be used as the designated server.

5.5 Speeding up Synchronization using a "drift file"

Synchronization can take up to an hour to reach acceptable accuracy (see Section 1.4). This time can be drastically reduced using a *drift file* – a logfile in which the *ntpd* service records its latest computation of the local clock drift.

Both disciplined servers and clients benefit from using the drift file. It is not needed by an undisciplined server, since it is does not reference external clocks.

To configure *ntpd* to use a drift file, you need to append your ntp.conf configuration file with the keyword "driftfile" followed by the path of the drift file, as shown in the example below.

```
# ntp.conf
# Client connected to a single server
# Drift file is used to speed up synchronization with server

server 10.10.10.242         # specify the IP address of your time server

driftfile C:\WINDOWS\SYSTEM32\DRIVERS\ETC\ntp.drift
```

Specifying the drift file in ntp.conf for a Windows XP client (connecting to server with IP address 10.10.10.242)

The first time you start your NTP service there will not be any drift file to initialize from, and so a full initialization must take place. After this service has run for an hour or so, it will create a ntp.drift file in the location you specified, and update it every hour. The next time you restart the service, it will use this file to speed up the initialization.

6 Monitoring Synchronization

The NTP distribution provides facilities to monitor how well your computers are synchronized.

6.1 Checking Synchronization Offset using ntpq

The *ntpq* utility [Mills, 2002, ntpq] lets you query how well *ntpd* is synchronizing a computer to its reference server(s). This is most commonly used to query the time difference between a computer and its servers. Note that *ntpq* will only work on a machine with an NTP service running.

Windows

To run *ntpq* on Windows:

1. Click **Start**, click **Programs**, click **Seeing Machines**, click **NTP FastTrack 1.0**, click **NTP Utilities Command Prompt**. A command prompt will appear with the working directory set correctly.
2. Type:
   - `ntpq -p`

An ASCII table of information will then appear, as shown in Figure 11. Table 2 explains the fields of this table.

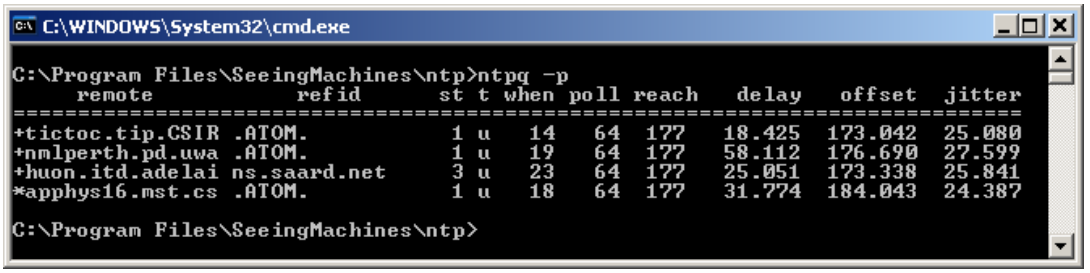

Figure 11 – The output from the command ntpq –p (Windows command prompt)

The *ntpq* output shown in Figure 2 is interpreted as follows: the stratum 1 server "appyhs16.mst.cs" has been the server selected for synchronization. Currently there is a 0.184 second time difference between the machine and this server, which will reduce over time.

Linux

To run *ntpq* on Linux:

1. Change to the ntpq directory using 'cd /usr/local/bin'.
2. Type:
   - `ntpq -p`

An ASCII table of information will then appear, similar to that shown in Figure 11. Table 2 explains the fields of this table.

Field Abbrev.	Full name	Explanation	Units
remote	Remote server name	The name of the NTP server. The name is preceded with a special character indicating the status of the server: The most important of these are "*" the clock has been selected for synchronization "x" the server is considered to be incorrect "+" the server was considered for synchronization. "blank" the server has been discarded. This can happen while a server is initializing. For an explanation of other characters, refer to [Dalton,1997]	-
refid	Reference ID	The IP address of the server, or name of the external server.	-
st	Stratum	The stratum of the server. Lower stratum number servers are considered more accurate.	-
t	Type	This indicates the "mode" of the NTP server. We are only interested in the following modes: "l" - local – A server with an undisciplined local clock will run in this mode "u"- unicast – point to point communication. Any client or server synchronizing from another server should have this as the mode.	-
when	when	The time since the last response from the server	seconds
poll	Poll Period	How often the client is querying the server.	seconds
reach	Reachability	Shows how successful the client has been in reaching the server. A reach of 377 indicates all recent queries have been answered.(This is an 8-bit register shown in octal notation)	-
delay	Round trip time	The time taken for the client to receive a reply packet from the server once it sent a query. The smaller the better.	milliseconds
offset	Time difference	The time difference between the client clock and the server clock. This is the main field of interest.	milliseconds
jitter	Dispersion	This represents the variation in offset measurements between samples. If this number exceeds 100 then the client will have trouble synchronizing with the server.	milliseconds

Table 2 - Interpreting output from the "ntpq –p" command [Dalton,1997]

7 References

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Windl, U. Dalton, D. Martinec, M. **The NTP FAQ and HOW-TO**

http://www.eecis.udel.edu/~ntp/ntpfaq/NTP-a-faq.htm
February 2002

Minor, N. **A Survey of the NTP Network**

http://www.media.mit.edu/~nelson/research/ntp-survey99/
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8 Glossary

Client
A machine requesting data from a server.

Daemon
A process that performs its task quietly in the background while you using other applications. The Linux equivalent of a Windows Service.

Drift file
A log file used by a ntpd client to minimize the time taken to synchronize to another computer.

Disciplined Server
A server which uses other more accurate (lower stratum) servers to compensate for the drift of its internal clock.

Event Viewer
A Windows tool for visualizing system "events". ntpd log information is viewed using the Event Viewer.

IP address
A unique identifier for a computer on a network.

Millisecond
1 millisecond = 0.001 second.

NTP
Network Time Protocol - a protocol for synchronizing computer clocks.

ntpd
The application responsible for implementing NTP. ntpd can act as a client or server or both. On Windows it runs as a Windows Service, on Linux it runs as a daemon. Included in the NTP Distribution.

NTP Distribution
A freeware software implementation of NTP (see www.ntp.org).

ntpq
A program used to query NTP servers, included in the NTP Distribution. Primarily for monitoring the time difference between a client and a server.

Offset
The time difference (usually in milliseconds) between two computers.

Server
A computer supporting one or more client computers. Each client computer is dependant on the server, but not vice versa.

Stratum
A level in the NTP server hierarchy. The lower a server's stratum number, the more accurate its time is considered to be.

SNTP
Simple Network Time Protocol - a simpler and less accurate version of NTP.

Undisciplined Server
A server which uses its local clock as the UTC reference time.

UTC
Universal Time Coordinated – the world wide absolute time standard, independent of time zones.

Windows Service
A Windows operating system process that performs its task quietly in the background while you using other Windows applications. The Windows equivalent of a Linux daemon.