

2023

Block Ads Network-wide with A Raspberry Pi-hole



<https://discourse.pi-hole.net/u/jpgpi250>

13-3-2023

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1. About this manual.

Using this guide will turn your Raspberry pi into a secure, manageable and stable pi-hole system.

If you are reading this document, using Adobe Reader, you may click on a hyperlink to content in this document. Use the combination <Alt> <left arrow> to return to the previous location.

"Back" and "Forward" buttons can also be added to the toolbar. If you right-click on the toolbar, under "Page Navigation", they are referred to as "Previous View" and "Next View".

This document is hosted on [GitHub](#), you can open the document (pdf), using this [link](#).

Copying and pasting from this manual into [Putty](#) doesn't seem to work all the time. If you get an error, try typing the command...

2. Buy.

You can buy this anywhere, I bought them at Conrad (included links). If you buy them at Conrad, ensure you use the country specific links ([conrad.de](#), [conrad.be](#), [conrad.nl](#) ...), this to get the proper payment and delivery options!

- Raspberry pi:
 - o Raspberry Pi® 3 Model B 1 GB w/o OS (10/100 Ethernet - item no.: [1419716](#)) **OR** Raspberry Pi® 3 Model B+ 1 GB w/o OS (Gigabit Ethernet - item no.: [1668026](#))
 - o Banana Pi® B+ enclosure Black RB-Case (item no.: [1274195](#))
- SD card: Ensure you buy a class 10 card. You'll need an SD adapter to format and write the SD card.
 - o microSDHC card 32 GB Transcend 32GB CL10 MICRO SDHC CARD Class 10 (item no.: [416521](#))
 - o Transcend MicroSD™ Adapter auf SD (itm no.: [1413689](#))
- Power Supply: If you don't have a spare one.
 - o power supply unit Black RB-Netzteil3-B (item no.: [1429556](#))

3. Download.

- [Putty](#), ensure you download a version including PuTTYgen.
- [WinSCP](#)
- [Win32DiskImager](#)
- [SDFormatter](#)
- [Raspberry Pi OS \(32-bit\) Lite](#) (previously called Raspbian). This document was written, using the February 21st 2023 [release](#), Kernel version 5.15
- [MD5 & SHA Checksum utility](#). Whenever possible, verify the integrity of your download, using the provided checksum.

4. Raspberry pi Installation.

1. Preparing the SD card.

- Format the SD card, using SDFormatter.
- Extract 2023-02-21-raspbios-bullseye-armhf-lite.img.xz, this zip contains a single image file.
- Write the extracted file (2023-02-21-raspbios-bullseye-armhf-lite.img) to the SD card, using Win32DiskImager.
- You need to create a file called "ssh" (**no extension**) in the boot partition to enable SSH (read the [release notes](#)).

This PC > boot (D:)

Name	Date modified	Type	Size
LICENSE.oracle	25-Nov-16 5:56 PM	ORACLE File	19 KB
start.elf	25-Nov-16 4:35 PM	ELF File	2,756 KB
start_cd.elf	25-Nov-16 4:35 PM	ELF File	619 KB
start_db.elf	25-Nov-16 4:35 PM	ELF File	4,839 KB
start_x.elf	25-Nov-16 4:35 PM	ELF File	3,813 KB
ssh	08-Dec-16 12:53 P...	File	0 KB

cted 0 bytes

- You need to create a file called “userconf.txt” (single line, no additional linefeed) in the boot partition to create the default user (read [here](#)), content (user **pi**, password **raspberrypi**, as in previous images). Read the instructions in the news item to generate a different initial password.

```
1 pi:$6$/4.VdYgDm7RJ0qM1$FwXCeQgDKkqrOU3RIRuDSKpauAbBvP11msq9X58c8Que2l1Dwq3vdJMgiZlQsBEXGaY5esVHGBNbCxKLVNqZW1
```

Encrypted password:

\$6\$/4.VdYgDm7RJ0qM1\$FwXCeQgDKkqrOU3RIRuDSKpauAbBvP11msq9X58c8Que2l1Dwq3vdJMgiZlQsBEXGaY5esVHGBNbCxKLVNqZW1

- I’ve tried several solutions (Win32DiskImager, Etcher) to backup and restore (clone) the SD card, unfortunately, they all fail, due to the “Not enough space error”. Most internet search results recommend to shrink the size of the Linux partition, before creating the image, this to allow successful cloning, an additional Linux machine is often required. **If you want to successfully backup / restore (clone) your SD card**, you may want to execute the steps, described in [this document](#), before you start building your pi-hole.
 - Insert the SD card in the Raspberry pi (power disconnected).
2. Preparing your DHCP server.
You probably have an existing DHCP configuration. It is advised you make a static entry for the Raspberry pi (IP address – MAC address). This will ensure the Putty and winSCP configurations will still be functional, if you decide to reinstall from scratch. The [static IP](#) configuration will overwrite the values from the DHCP server.
 3. Power on the Raspberry pi.
You only need to connect the power and an Ethernet cable. There is no need for a keyboard, mouse or HDMI monitor.
 4. Use Putty on your (Windows) workstation to connect to the Raspberry pi.
 - Session / Host Name (or IP address): enter the IP address
 - Connection / Data / Auto-login username: pi
 - Session / Saved Sessions: Enter a name for the device and click ‘Save’
 - Click ‘Open’
 - The default password is ‘**raspberrypi**’
 5. Resize the Linux partition.
If you disabled automatic partition expansion, you need to resize the partition, following the instructions in [this document](#), this to allow for successful [backup](#) / restore (clone).

6. Configure the static IP address.

Reference: <http://www.suntimebox.com/raspberry-pi-tutorial-course/week-3/day-5/>, read the comment from BK near the end of the page.

```
sudo nano /etc/dhcpd.conf
```

Enter your Raspberry pi's static IP address and your network's gateway, we are using the OpenDNS servers.

```
interface eth0
static ip_address=<your Raspberry pi's static address>
static routers=<your networks gateway>
static domain_name_servers=208.67.222.222 208.67.220.220
```

Now is the time, if you haven't already done so, to configure the static DHCP entry. To find the MAC address:

```
ifconfig
```

Copy the **HWaddr** (that is the MAC address) from **eth0**

7. Update the Raspberry pi.

```
sudo apt-get update && sudo apt-get -y upgrade
```

Wait for the updates to install...

8. Reboot the Raspberry pi.

This is required to activate the static IP address and possible Raspberry pi specific patches to the Linux kernel.

Your Putty session will disconnect, wait a few seconds, right click the Putty frame and select 'restart session'.

```
sudo reboot
```

9. Repair the update (if a kernel patch has been installed).

If a Linux kernel patch has been installed, you need to issue the following commands to complete/repair the raspbian update:

```
sudo apt-get update
sudo apt-get -y --fix-broken install
sudo apt-get -y autoremove
```

10. Install mail (assumes valid gmail account).

Using another service than gmail may require specific configuration settings.

Reference: <https://websistent.com/how-to-use-msmtp-with-gmail-yahoo-and-php-mail/>

Reference: <https://websistent.com/msmtp-cron/>

We will be installing MSMTTP, you will need to [upgrade](#) the system, if you haven't already done so, before this works!

```
sudo apt-get -y install msmtp
```

Wait for the installation to complete...

Create a symbolic link for sendmail (required for [webmin](#), see reference)

```
sudo ln -s /usr/bin/msmtp /usr/sbin/sendmail
```

Create the MSMTTP configuration:

```
sudo nano /etc/msmtprc
```

Google changed the [policy](#) for less secure apps. As a result you need to generate an app password, and use this password in your configuration. In order to activate this option (read [here](#) how to generate an app password), 2FA is required. Ensure you have sufficient 2FA recovery options (device, phone, google authenticator app, backup codes).

Replace <your account name> (twice) with a valid gmail address and update <your app password>.

```
defaults
tls on
auth on
host smtp.gmail.com
port 587
user <your account name>
password <your app password>
aliases /etc/aliases
account default
from <your account name>
```

Edit the MSMTTP aliases configuration.

```
sudo nano /etc/aliases
```

Add the following (replace the account information)

```
default: <your account name>
```

Optionally, send a test mail, you can read more about this [here](#), this simple test sends a mail without a subject (replace the account information):

```
echo "msmtp test mail" | msmtp -a default <your account name>
```

You also will get some mails, while making changes to the [webmin](#) configuration.

11. Setup Key authentication

Generate the authentication keys on your Raspberry pi

```
ssh-keygen -t rsa -C "raspberrypi"
```

Accept the defaults

If you didn't already setup WinSCP on your (Windows) workstation:

- Open WinSCP, select 'New Site'
- File protocol: SCP
- User name: pi
- Password: raspberry
- Click 'Advanced'
- Environment / SCP/shell /Shell: sudo su –
- Click "OK"
- Click "Save"

Login, using WinSCP

- Select the saved session
- Click "Login"
- Select Options / Preferences from the WinSCP menu
- Select Environment / Interface
- Check Commander
- Select Panels
- Check Show hidden files

Browse to the pi .ssh directory (/home/pi/.ssh)

Copy id_rsa and id_rsa.pub to your (Windows) workstation (It's recommended you create a sources/installation/key folder for your Raspberry Pi, containing all the necessary files)

Rename id_rsa.pub to **authorized_keys** (no extension) and copy it back to the .ssh folder. If you want to restrict SSH logins to particular IP addresses, check out this [reference](#).

Start [PuTTYgen](#) on your (Windows) workstation.

- Select "Load"
- Select the "All files" type
- Browse to your sources/installation/key folder and select id_rsa
- Click "Open", Confirm the import
- Click "Save private key"

- Confirm you want to save the key without a passphrase
- Type an appropriate key name and save the private key file (.ppk)

Configure Putty to use the key

- Open Putty, select the saved session, click "Load"
- Connection / Data / Auto-login username: pi
- Connection / SSH / Auth
- Click "Browse", select the private key file you created (.ppk)
- Session
- Click "Save"

Test your configuration, open a new Putty session, you should be logged on automatically.

Configure WinSCP to use the key

- Open WinSCP, select the saved session, click "Edit"
- Click "Advanced"
- SSH / Authentication
- Private key file
- Click "..." (Browse), select the private key file you created (.ppk)
- Click "OK" (closes advanced)
- Empty the password field
- Click "Save"

Test your configuration, open a new WinSCP session, you should connect, using the private key.

In order to ensure key security, apply the following:

```
sudo chown pi:pi /home/pi/.ssh/authorized_keys
sudo chmod 600 /home/pi/.ssh/authorized_keys
sudo chown pi:pi /home/pi/.ssh/id_rsa
sudo chmod 600 /home/pi/.ssh/id_rsa
sudo chown pi:pi /home/pi/.ssh/id_rsa.pub
sudo chmod 644 /home/pi/.ssh/id_rsa.pub
```

Further increase security by adding the IP address of your workstation(s):

```
sudo nano /home/pi/.ssh/authorized_keys
```

This file contains the key, used to allow authentication.

Insert the following at the beginning of the line (before the key) to add the IP address limitation (replace the IP address with the IP address of your workstation). A space after the last double quote is required:

```
from="192.168.x.x"
```

Specifying multiple IP address is an option (enter multiple IP addresses, allowed to use SSH):

```
from="192.168.x.x,192.168.x.y"
```

12. Install Webmin (version 2.020).

Reference: <http://www.webmin.com/deb.html>

Install the dependencies

```
sudo apt-get -y install perl libnet-ssleay-perl openssl libauthen-pam-perl  
sudo apt-get -y install libpam-runtime libio-pty-perl apt-show-versions python  
sudo apt-get -y install shared-mime-info
```

Download the package.

```
sudo wget http://prdownloads.sourceforge.net/webadmin/webmin_2.020_all.deb
```

Install the package, this may take a while...

```
sudo dpkg --install webmin_2.020_all.deb
```

13. Additional system configuration (webmin).

The Webmin URL: <https://<Your Raspberry pi's IP address>:10000/>

The username is pi, the password is raspberry, unless you've already [changed](#) that.

- Webmin / Webmin configuration / Logging:
 - o Requires [mail setup](#)!
 - o Send email for actions in: Select **Only log actions in ..**
 - Select (CTRL click) **Software Package Updates**
 - Select (CTRL click) **Webmin Configuration**Failing to make a selection (leaving the setting to **Log actions in all modules**) will cause a mail storm from the **Webmin Scheduled actions**
- System / Software Package Updates / Scheduled Upgrades:
 - o Requires [mail setup](#)!
 - o Check for updates on schedule: **Yes, every day.**
 - o Email updates report to: enter a valid (g)mail address.
 - o Action when update needed: **Install any updates.**

The webmin configuration screen doesn't allow you to set the time for scheduled updates. You can change the time, using the "Edit Cron Job" editor (system / scheduled cron jobs / click on "/etc/webmin/package-updates/update.pl"), make sure it is scheduled to run before your [needrestart](#) script will run (allow sufficient time to complete large updates).

- Hardware / system time / change timezone:
 - o Select the correct time zone

If you know the name of your time zone, you can also change it on the command line. Example for “Europe/Brussels”:

```
sudo timedatectl set-timezone Europe/Brussels
```

- Webmin / Webmin Configuration / IP Access Control:
 - o Select “only allow from listed addresses”
 - o Enter allowed IP addresses (at least the **static** IP address of your workstation)
- Servers / SSH Server / Authentication:
 - o Requires working [key authentication](#)!
 - o Allow authentication by password? **No**

Need more info? The manual (by Jamie Cameron) can be found [here](#), Webmin issues [here](#) (GitHub).

14. Time (system clock) configuration.

The latest versions of some linux distributions, including Raspbian, come with a service, called ‘systemd-timesyncd.service’. This minimalistic service (not my words, see the [man page](#)) may be used to synchronize the local system clock. It also saves the local time to disk (/var/lib/systemd/clock) every time the clock has been synchronized. If you don’t mind the additional writes to your SD card, you may use this service to keep time synchronized, you will need to configure the service.

To check if the service is available:

```
sudo service systemd-timesyncd status
```

On a fresh installed Raspbian system, this will show ‘active (running)’

To configure the service:

Goto <http://support.ntp.org/bin/view/Servers/NTPPoolServers>

Select the region you are in, there will be a list of NTP servers for your region.

```
sudo nano /etc/systemd/timesyncd.conf
```

Modify the line ‘#NTP=’ into (replace ‘debian’ with the region you selected, e.g. for Europe: ‘0.debian.pool.ntp.org’ becomes ‘0.europe.pool.ntp.org’. It is a space-separated list!

```
NTP=0.debian.pool.ntp.org 1.debian.pool.ntp.org 2.debian.pool.ntp.org 3.debian.pool.ntp.org
```

Restart the ‘systemd-timesyncd’ service

```
sudo systemctl daemon-reload  
sudo service systemd-timesyncd restart
```

To verify time synchronization, enter

```
timedatectl
```

The reply should indicate that the System clock is synchronized.

If you are happy with using the 'systemd-timesyncd' service, move on to the next section ([install DNS utils](#)).

If you prefer to use a more robust NTP service, continue.

A package, available for almost all linux distributions is NTP. This package installs a daemon that will keep time synchronized.

The NTP server package isn't installed by default in this version of Raspbian.

Install the NTP package:

```
sudo apt-get install ntp
```

Goto <http://support.ntp.org/bin/view/Servers/NTPPoolServers>

Select the region you are in, there will be a list of NTP servers for your region.

```
sudo nano /etc/ntp.conf
```

Find the line (<ctrl-W>) # pool: <http://www.pool.ntp.org/join.html>

There are four (4) lines below this line. Replace the DNS names with the DNS names from the list Example: Europe.

```
server 0.europe.pool.ntp.org iburst  
server 1.europe.pool.ntp.org iburst  
server 2.europe.pool.ntp.org iburst  
server 3.europe.pool.ntp.org iburst
```

Stop the NTP service

```
sudo /etc/init.d/ntp stop
```

Stop the 'systemd-timesyncd' service (the minimalistic NTP service that might be running on your system and disable it permanently (you can enable it again if you change your mind).

```
sudo service systemd-timesyncd stop  
sudo systemctl disable systemd-timesyncd
```

Force NTP to sync, even if the current system time is incorrect.

```
sudo ntpd -gq
```

Start the NTP service

```
sudo /etc/init.d/ntp start
```

Check NTP server synchronization status.

```
ntpq
```

At the ntpq prompt, enter **pe**.

```
ntpq> pe
```

You'll get a list of servers, the primary server is marked with an asterisk (*). It may take a while for the synchronization to become active, repeat the command

To quit the ntpq prompt, enter **quit**

```
ntpq> quit
```

15. Install DNS utils.

It is recommended to check your system's DNS capability before installing pi-hole.

```
sudo apt-get -y install dnsutils
```

Check if name resolution is functional, remember we configured the [OpenDNS](#) servers.

```
dig google.com
```

5. Pi-hole installation (version v5.15.5).

1. What will pi-hole do for you?

Pi-hole will provide an answer for all domain queries, to any device that uses pi-hole as DNS server. The answer can be the real address for the domain or an answer that will prevent the device loading content from this domain. The format of the answer can be configured, by adding a setting to /etc/pihole-FTL.conf. The blocking mode options can be found [here](#). Pi-hole uses '**unspecified IP blocking**' by default (recommended).

```
Mar 3 11:48:48 dnsmasq[5851]: query[A] collector-hpn.ghostery.net from 192.168.2.228
Mar 3 11:48:48 dnsmasq[5851]: forwarded collector-hpn.ghostery.net to fdaa:bbcc:ddee:2::5552
Mar 3 11:48:48 dnsmasq[5851]: query[AAAA] collector-hpn.ghostery.net from 192.168.2.228
Mar 3 11:48:48 dnsmasq[5851]: forwarded collector-hpn.ghostery.net to fdaa:bbcc:ddee:2::5552
Mar 3 11:48:48 dnsmasq[5851]: reply collector-hpn.ghostery.net is <CNAME>
Mar 3 11:48:48 dnsmasq[5851]: reply collector-hpn.privacy.ghostery.net is 52.45.85.77
Mar 3 11:48:48 dnsmasq[5851]: reply collector-hpn.privacy.ghostery.net is 54.86.217.191
Mar 3 11:48:48 dnsmasq[5851]: reply collector-hpn.ghostery.net is <CNAME>
Mar 3 11:48:48 dnsmasq[5851]: reply collector-hpn.privacy.ghostery.net is NODATA-IPv6
```

The data, used in the demo, is extracted from an operational system, using numerous [block lists](#). All blocked entries are displayed in **magenta**, resulting in an unspecified IP.

2. Installation.

Reference: <https://pi-hole.net/>

- Automated install

I've had issues with this (DNS error) see below for an alternative

```
curl -L https://install.pi-hole.net | bash
```

- Alternative Semi-Automated install

```
wget -O basic-install.sh https://install.pi-hole.net
```

```
chmod +x basic-install.sh
```

```
sudo ./basic-install.sh
```

- Read the informational dialogs, select **"Yes"** when the **"Static IP Needed"** dialog appears.
- Select **"Yes"** (Set static IP using current values) to accept the proposed IPv4 values. Do NOT select one of the other options unless you know how to manually configure TCP settings. A faulty configuration will make your pi remotely inaccessible.
- Select the interface, eth0 is the wired interface on Raspbian. The interface choice will only appear if you have multiple interfaces.
- Read the IP conflict dialog (this should never be an issue if you [prepared your DHCP server](#)).
- Select DNS servers (I've been using the OpenDNS servers).
- Select the third party lists you want to use (the latest version of the installer only offers a single list) and confirm.
- Select **"On (Recommended)"** to install the web admin interface. Your choice will be recorded, using the INSTALL_WEB setting in /etc/pihole/setupVars.conf.
- Select **"On (Recommended)"** to install the web server (lighttpd), unless you already installed a different web server. Using a different web server is not covered in this manual.
- Select **"On (Recommended)"** to log queries. Your choice will be recorded, using the QUERY_LOGGING setting in /etc/pihole/setupVars.conf.
- Select a privacy mode for FTL that suits you, defaults to 0 (Show everything), recommended.
- Wait for the installation to complete...
- Write down the web interface admin password. You can [change](#) it immediately, if required!
- Notice the IPv6 address, listed in the dialog. If the address is incorrect, you may experience strange behavior. Check the [forum IPv6 topics](#) for a solution.
- Don't forget to configure the correct [DNS settings](#)...

3. Upgrading

You may notice a message "Update available!"

Pi-hole v5.15 · **Update available!** **FTL** v5.20.1 **Web Interface** v5.18.1 · **Update available!**

To install updates, run `pihole -up`.

To find your pi-hole version

```
pihole version
```

You can upgrade using the command

```
pihole updatePihole
```

You can automatically install updates (**not recommended**), if any. You'll need to add a [cron job](#).

```
sudo nano /etc/cron.d/piholeupdate
```

Add the update job by adding the following, modify the time to meet your requirements.

```
# Pi-hole: Update Pi-hole
30 2 * * 7 root PATH="$PATH:/usr/local/bin/" pihole updatePihole
```

6. Change your DNS settings.

Pi-hole won't do anything, unless you modify the DNS settings on your (Windows) workstation(s).

If you have a DHCP server on your network, change the DNS settings in DHCP server setup. The first DNS server should be <Your Raspberry pi's IP address>. Don't configure a second DNS server, unless you have two pi-holes. You'll need to reboot your workstation for the new DNS setting to become active immediately.

If you're using a local DNS configuration, you'll have to change it on all the devices.

You'll also need to flush or [configure the DNS cache](#) on your (Windows) workstation.

```
ipconfig /flushdns
```

7. Change the default UNIX password.

The default password for the pi user is raspberry. In order to protect the system, you need to change this. We're using sudo to allow simple passwords. [Webmin](#) will also be accessible, using the new password.

```
sudo passwd pi
```

Enter the new password.

8. Change / Recover the admin page password.

You can change the admin page password, using putty.

Enter the following command:

```
sudo pihole -a -p
```

Enter the new admin page password (twice).

You can disable authentication by just pressing <Enter> (Blank for no password).

You can also remove the password by removing it from the configuration file.

```
sudo nano /etc/pihole/setupVars.conf
```

Remove everything after the equal sign.

```
WEBPASSWORD=
```

9. Adding a local LAN list

You have probably noticed you can get to the pi-hole admin page by entering <http://pi.hole/admin>.

This was achieved (older pi-hole versions) by creating a configuration file `/etc/pihole/local.list`. The latest version of pi-hole achieves this automatically, no need to make an entry in the configuration file. The file `/etc/pihole/local.list` is now a static file (contains a warning only). The file is overwritten when running `'pihole -g'` or `'pihole -up'`.

You can use the pi-hole solution to create custom names for your devices (different from the hostname), by using the web interface, click on 'Local DNS Records' and add the 'device name' and 'IP address'. Changes are saved in `/etc/pihole/custom.list`.

Due to the limitation of using the web interface, you can only use a single name for a device, example:

```
192.168.2.232 7730g
```

The [hosts file specification](#) however, allows multiple entries (names) for a single IP address, example:

```
192.168.2.232 7730geth0.localdomain 7730g.localdomain 7730geth0 7730g
```

Use the method below to overcome this limitation and / or **you plan to import your [clients into the database](#)**, using a script (sqlite3).

Both methods need a careful approach. In the section '[Raspberry pi installation](#)', '[Preparing your DHCP server](#)', I advised you to configure the DHCP server to make a static entry for the Raspberry pi (IP address – MAC address). The same approach should be used for clients. If the client isn't configured in such a way, it may receive a different IP address, when the DHCP lease has expired (read [this article](#), search for lease). The lease time usually (most routers)

default to 14 days (this may vary, depending on make and model). As long as you connect to the network within that period, no IP change will occur, however, if you take a three week holiday, you might be in for a surprise.

Create /etc/localdns.list:

```
sudo nano /etc/localdns.list
```

Content, you need to replace the IP addresses, hostnames and domainname, to match your own environment, on Windows you can find your domain name by entering 'ipconfig /all' (look for Connection-specific DNS Suffix), on linux you can find your domain name by entering 'dnsdomainname'. Example:

192.168.2.5	s9.localdomain	s9
192.168.2.53	macbook.localdomain	macbook
192.168.2.102	ps4.localdomain	ps4

You can enter as many entries (lines) as you need.

Now we need to tell the system to use the newly created list (/etc/localdns.list).

Create a new dnsmasq configuration file:

```
sudo nano /etc/dnsmasq.d/localdns.conf
```

Content (you need to change the 'domain' and 'local' value to match your own):

```
domain=localdomain
expand-hosts
local=/localdomain/
addn-hosts=/etc/localdns.list
```

All we have to do now is activate the new configuration:

```
sudo service pihole-FTL restart
```

As soon as the restart is completed, you can use the dnsname to get to your devices, e.g., 'ping ps3', 'nslookup ps3', 'dig ps3'. Depending on your systems settings, it might be required to use the full name, e.g. 'ping ps3.localdomain'. You can change that, but these changes need to be done on the workstation (windows 10, linux, mac).

Warning: All files in /etc/dnsmasq.d are saved when using 'Teleporter' (web interface / Settings / Teleporter / Export), the file /etc/localdns.list however, is a pi-hole customization, thus NOT saved by 'Teleporter'. Always keep a backup copy on a different machine.

10. Windows Whitelist.

The windows registry

(\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\NlaSvc\Parameters\Internet) key, contains information, needed to determine the systems internet connection status.

In order to correctly update the windows internet status (network icon in the system tray) you need to add whitelist exceptions.

- Open the pi-hole admin page: <http://<Your Raspberry pi's IP address>/admin/>
- Select "Domains" from the menu.
- Select the "Domain" tab, add the following entries(windows 7 and 10 entries are listed), select "Add to Whitelist":

```
www.msftncsi.com
dns.msftncsi.com
ipv6.msftncsi.com
www.msftconnecttest.com
ipv6.msftconnecttest.com
```

Pi-hole entries can be made, using the pi-hole admin page. The next section(s) will explain alternate methods to enter new entries.

An alternative approach would be to use a 'Regex filter' or 'Wildcard whitelist' entries. Remember that **whitelist entries always win**, if a domain matches a whitelist entry ('Exact whitelist', 'Regex whitelist' or 'Wildcard whitelist'), pi-hole will allow the domain, regardless of what may be on the block lists.

It is recommended to be extremely careful, when using 'Regex whitelist' or 'Wildcard whitelist', because it might open the door for domains you don't want.

Example, the regular expression ("Regex filter" tab)

```
(\.|^)\.msftncsi\.com$
```

would be a replacement for 3 of the "Domain" entries in the above list, however, the domain tracker.msftncsi.com (example, doesn't currently exist) would also be allowed, which isn't really what we try to achieve. If you want to test what a new regular expression does or doesn't achieve, [regex101](#) allows you to test your regex, [regexper](#) explains how your regex works.

11. Modify lists using the 'pihole' command.

If you simply enter 'pihole' on the command line of your putty session, you will be presented with a list of possible options.

You can add an entry to a list by using the appropriate 'pihole' command.

Example: add the domain 'ipinfo.io' to the whitelist (always allow access to this site, even if the domain is in a block list)

```
pihole -w ipinfo.io
```

This method can be used to add whitelist (-w), blacklist (-b), wildcard blacklist domains (wildcard), regex blacklist domains (regex).

pihole-FTL will pick up the changes immediately, no need to restart pihole-FTL (part of the 'pihole' command).

12. Modify lists using sqlite3.

The pi-hole lists are no longer separate files (adlists.list, black.list, whitelist.txt), all data is now maintained in the sqlite3 database (/etc/pihole/gravity.db).

You can explore or modify the database by installing phpLiteAdmin, a web interface that will give you access to all sqlite3 databases. The installation (NOT part of pi-hole – NOT supported) is described [here](#).

You can add an entry to a list by using the appropriate sqlite3 command. The last version of pi-hole doesn't install the [sqlite3](#) package, sqlite3 is embedded in pihole-FTL.

Example: add the domain 'ipinfo.io' to the whitelist (always allow access to this site, even if the domain is in a block list).

```
sudo pihole-FTL sqlite3 /etc/pihole/gravity.db  
insert or ignore into domainlist (domain, enabled) values ("ipinfo.io", 1);  
.quit
```

OR add the domain and comment

```
sudo pihole-FTL sqlite3 /etc/pihole/gravity.db  
insert or ignore into domainlist (domain, comment, enabled)  
values ("ipinfo.io", "IP Address Data", 1);  
.quit
```

Note you can split the command on multiple lines, ";" marks the end of the command. You will see "...>" on the screen after the first line, enter the second line after this.

pihole-FTL does NOT pick up the changes immediately, you'll need to reload the configuration.

```
pihole restartdns reload
```

Adding a single entry, using sqlite3 requires more effort than using the 'pihole' command, however, using sqlite3 is very useful to add multiple entries from a text file. This will be explained in the [regex](#) section.

13. Adding Wildcard sites to the blacklist.

Wildcard configuration (/etc/dnsmasq.d/03-pihole-wildcard.conf) is no longer supported by pi-hole, instead [regular expressions](#) are used.

You may still want to use wildcards, as it is a valid dnsmasq feature. FTLDNS, used by pi-hole, is based on dnsmasq. If you want to block an entire domain and don't want to use regular expressions, create an additional configuration file for dnsmasq.

Warning! The entries in this list are **NOT affected** by the **disable** function in the pi-hole web interface. A change of the configuration file requires a restart ('sudo service pihole-FTL stop / sudo service pihole-FTL start')

Warning! The entries in this list do NOT trigger the [CNAME feature](#). If you want to create an entry that blocks CNAMEs, you need to use a regular expression.

```
sudo nano /etc/dnsmasq.d/wildcard.conf
```

In this example, we will block the entire ligatus.com domain, using null blocking. Add the following line to the file (only use a single entry per domain, either the IPv4 example **OR** the IPv4 and IPv6 example):

```
# Entry for IPv4 only
address=/ligatus.com/0.0.0.0
# Entry for IPV4 and IPV6
address=/ligatus.com/#
```

You can add multiple 'address' lines

Reload and restart the FTLDNS service

```
sudo service pihole-FTL stop
sudo service pihole-FTL start
```

14. Regular expressions.

As of pi-hole v4.0, regular expressions are used, to block domains. You can add wildcards or regular expressions, using the web interface (settings), the pihole command, or by editing the database. In pi-hole v4.1, PRIVACYLEVELS are introduced. By default, the level is 0 (Show everything). Regular expressions cannot be used if privacy level 4 (Disabled statistics) is used. The privacy level can be changed in the web interface (Settings / Privacy). The privacy level is stored in /etc/pihole/pihole-FTL.conf.

To add a regular expression, using the 'pihole' command (example block 'doubleclick', notice the double quotes!):

```
pihole regex "(^|\.)doubleclick\.net$"
```

To add a regular expression using sqlite3 (example block 'facebook', notice the double quotes! - the regex can also be copied [here](#), discussion [here](#)):

```
sudo pihole-FTL sqlite3 /etc/pihole/gravity.db
insert or ignore into domainlist (domain, type, enabled)
```

```
values ('^(.+\\.)?(facebook|fb(cdn|sbx)?|tfnw)\\.([^.]+)$', 3, 1);  
.quit
```

Note you can split the command on multiple lines, “;” marks the end of the command. You will see “...>” on the screen after the first line, enter the second line after this.

As you can see, as opposed to the sqlite3 [whitelist](#) example, a type field is used. It isn't used in the whitelist example, because the default value is zero. [Here](#), you can find an overview of the different types and some additional information on the domainlist database table.

Another example of regular expressions (block amp pages), reference [here](#):

```
^(.+[_.-])?amp(project)?\.
```

You can learn more about regular expressions in [this](#) pi-hole document. Examples of regular expressions are provided [here](#).

Adding a single entry, using sqlite3 requires more effort than using the 'pihole' command, however, using sqlite3 is very useful to add multiple entries from a text file. A well known and used list of regular expressions can be found [here](#). You can add these regular expressions by running /home/pi/regex.sh:



Click on the icon to view the script in a browser. Copy the content and make the script executable (sudo chmod +x /home/pi/regex.sh). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

The web interface identifies a domain, blocked due to a regex match as follows (example):

AAAA	www.facebook.com	Blocked (regex blacklist)
------	------------------	---------------------------

Clicking on the link ('Blocked (regex blacklist)') will open a new page (<CTRL> click if your browser doesn't support this), showing the regex (highlighted), responsible for blocking.

<pre>^(.+.)??(facebook .*fb.+).(com net)\$</pre>	Regex blacklist ▾	Enabled <input checked="" type="checkbox"/>
--	-------------------	---

You can either delete the regex, NOT recommended, as it will allow all domains, previously blocked due to the regex OR whitelist the domain on the first screen (query Log).

15. Deep CNAME inspection

Several articles (search for 'CNAME cloaking') describe the latest method advertisers and trackers use to bypass ad blockers. Naturally, ad blockers, including pi-hole, have found a solution for this.

'Deep CNAME inspection' is enabled by default, you can disable it (NOT recommended) by adding

```
CNAME_DEEP_INSPECT=false
```

to `/etc/pihole/pihole-FTL.conf`.

The web interface identifies a domain, blocked due to a CNAME match as follows (example):

AAAA	fonts.gstatic.com (blocked gstaticadssl.l.google.com)	Blocked (gravity, CNAME)
------	--	--------------------------

This example shows `fonts.gstatic.com` is NOT in any block list (use `'pihole -q'` to verify), but `gstaticadssl.l.google.com` (the CNAME) is (`gstaticadssl.l.google.com` is on 4 of my block lists), thus `fonts.gstatic.com` (the original request) will be blocked because of the CNAME. You can use the command `'dig @8.8.8.8 A fonts.gstatic.com'` to verify the CNAME relation. This example is provided, using my block list set, it may not produce the same result on your system, because you don't use different block lists.

Pi-hole shows blocking, due to deep CNAME inspection, in the pi-hole log (`/var/log/pihole/pihole.log`). If a domain is blocked, due to deep CNAME inspection, you'll see something like (example used above):

reply fonts.gstatic.com is <CNAME>

reply gstaticadssl.l.google.com is blocked during CNAME inspection

Never whitelist a CNAME (`gstaticadssl.l.google.com` in the example). Several other, possibly undesired domains may use the same CNAME! In the above example, you would whitelist `fonts.gstatic.com` (**pi-hole developer recommendation**).

NextDNS, a DNS provider, has a [github page](#), explaining CNAME cloaking, and a list of companies (domains) that use this technique. In order to defend yourself against this practice, you can add these domains as regex (regular expressions), manually, or by running `/home/pi/NextDNS.sh`:



Click on the icon to view the script in a browser. Copy the content and make the script executable (`sudo chmod +x /home/pi/NextDNS.sh`). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with `'sudo'!`

The Adguard Team also has a [github page](#) (reported by [Sudoku](#)) with a list of companies (domains) that use this technique. Although a lot of the domains are already in the NextDNS list, you can add some additional domains (extracted from the [json file](#)) as regex (regular expressions), manually, or by running `/home/pi/AdguardTeam.sh`:



Click on the icon to view the script in a browser. Copy the content and make the script executable (`sudo chmod +x /home/pi/AdguardTeam.sh`). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with `'sudo'!`

16. Adding host lists.

Pi-hole comes with a default set of host lists (URL's), used to create the gravity list. Pi-hole stores the URLs in the database (`/etc/pihole/gravity.db` / table `adlist`).

These URLs are used every Sunday, using a cron job, to update the gravity (blocked domains) database (/etc/pihole/gravity.db / table gravity).

You can add entries to this table, using the web interface (Select "Adlists" from the menu), whenever you add an entry to the list, using the web interface, you need to rebuild the gravity list, using "pihole -g" (terminal) or "Tools" / "Update Gravity" (web interface menu).

To add entries to the list manually, using sqlite3 (example):

```
sudo pihole-FTL sqlite3 /etc/pihole/gravity.db
insert or ignore into adlist (address, enabled)
values ('http://someonewhocares.org/hosts/', 1);
.quit
```

Note you can split the command on multiple lines, ";" marks the end of the command. You will see "...>" on the screen after the first line, enter the second line after this.

You can also add an entry with a comment, see [modifying lists using sqlite3](#).

Some URL's, containing lists I added:

```
http://someonewhocares.org/hosts/
https://www.malwaredomainlist.com/hostslist/hosts.txt
http://winhelp2002.mvps.org/hosts.txt
http://www.hosts-file.net/download/hosts.txt
http://v.firebog.net/hosts/Easyprivacy.txt
# cryptojacking
https://raw.githubusercontent.com/hoshisadiq/adblock-nocoin-list/master/hosts.txt
https://gitlab.com/ZeroDot1/CoinBlockerLists/raw/master/list.txt
```

You should always check the format of a new host list, before adding it to your list. Not all lists can be parsed correctly.

An interesting set of lists, can be found [here](#). This page will let you choose from 3 sets of lists, I've been using the [non-crossed lists](#). This page will display a set of URLs that can be added. Using sqlite3, it is possible to add these list with a script. You can add these lists by running /home/pi/firebog.sh:



Click on the icon to view the script in a browser. Copy the content and make the script executable (sudo chmod +x /home/pi/firebog.sh). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

Some lists aren't compatible with pihole and need to be pre-processed in order to use them. I have been using lists from this [site](#). Use the script to download and process the lists to your local file system.



Click on the icon to view the script in a browser. Copy the content and make the script executable (`sudo chmod +x /home/pi/quidsup.sh`). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

After running this script, the result is a new folder `/home/pi/quidsup`. This folder contains two lists that can be used with pi-hole:

```
/home/pi/quidsup/notrack-blocklist.txt  
/home/pi/quidsup/notrack-malware.txt
```

To add this list to your set of lists, using sqlite3 (or the web interface)

```
sudo pi-hole-FTL sqlite3 /etc/pihole/gravity.db  
insert or ignore into adlist (address, enabled)  
values ('file:///home/pi/quidsup/notrack-blocklist.txt', 1);  
insert or ignore into adlist (address, enabled)  
values ('file:///home/pi/quidsup/notrack-malware.txt', 1);  
.quit
```

Notice we are using a local file, hence the "`file:///`".

If you have added new lists, using sqlite3 or a script, remember to activate the new lists:

```
pi-hole -g
```

Always remember to flush or [configure the DNS cache](#) on your workstation, to ensure correct responses, after adding new lists.

```
ipconfig /flushdns
```

17. Group Management

Up to pi-hole v4.3.2, all block lists were applied to all clients. This often was a dilemma for the administrator, a specific user may need or request access to a specific web page, the only option to grant the request was to whitelist the domain, unfortunately, that whitelist entry affected all users.

Pi-hole uses group management to overcome this limitation, use this wisely!

The developer's documentation, contains very detailed examples, on how to use group management, and can be found [here](#).

It's NOT always easy to get the desired result. You could for example exclude an 'adlist' for a specific group, but the domains in that 'adlist' may exist in multiple lists. Always use:

```
pi-hole -q <domain>
```


This, to verify if a domain exists on multiple 'adlists'. Excluding a specific 'adlist' from a group is pointless, if the domains in the list exist in multiple 'adlists'.

Remember, 'whitelist' entries always have precedence. You can block what you want, if there is a 'whitelist' or 'regex whitelist' entry, the domain will never be blocked!

Changes made in Group Management don't appear to take effect until you restart pi-hole-FTL.

```
pihole restartdns reload-lists
```

1. Groups.

A default group exists, the 'The default group'. By default, all clients, even the ones not defined in the 'Clients' section, are member of this group, you can change membership in the 'Clients' section. You can add a new group, using the web interface (web interface menu / Groups)

2. Clients

By default, there are no configured clients. You can add a client, using the web interface (web interface menu / Clients). A client must be a member of at least one group, by default, this will be the 'The default group'. If a client isn't a member of any group, nothing will be resolved (no internet). If you are using both IPv4 and IPv6 on your network, and want to allow the client to bypass a specific 'Domain' or not use a specific 'Adlist', you need to add a 'Client' entry for both the IPv4 and IPv6 'Client' address.

This setup needs a careful approach. In the section '[Raspberry pi installation](#)', '[Preparing your DHCP server](#)', I advised you to configure the DHCP server to make a static entry for the Raspberry pi (IP address – MAC address). The same approach should be used for clients. If the client isn't configured in such a way, it may receive a different IP address, when the DHCP lease has expired (read [this article](#), search for lease). The lease time usually (most routers) default to 14 days (this may vary, depending on make and model). As long as you connect to the network within that period, no IP change will occur, however, if you take a three week holiday, you might be in for a surprise.

If you have created /etc/localedns.list, as described [here](#) (local LAN list), you can use a script to add the IP addresses and a comment (last entry of the line) to your pi-hole configuration.



Click on the icon to view the script in a browser. Copy the content and make the script executable (sudo chmod +x /home/pi/clients.sh). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

3. Domains.

The 'Domains' list contains all whitelist, blacklist, regex whitelist and regex blacklist entries you have defined on your system. The steps, required to assign a whitelist, blacklist, regex whitelist or regex blacklist entry are very well explained in the [developer's documentation](#), thus NOT explained here.

4. Adlists

The 'Adlists' list contains all adlists you have defined on your system. The steps required to assign an 'adlist' entry are very well explained in the [developer's documentation](#), thus NOT explained here.

18. Group Management, a whitelist example.

I had a problem with my android devices, notifications didn't work anymore. I found a [hint](#) to the solution. Turns out a number of block lists started adding mtalk.google.com entries (example: alt2-mtalk.google.com).

A solution, using a **regex whitelist** entry, for **android devices only**:

1. Create the whitelist regex entry (web interface menu / tab "Regex filter" / Add to Whitelist):

```
^((alt)[0-9](-))?mtalk\.google\.com$
```

Result will look like this:

<code>^((alt)[0-9](-))?mtalk\.google\.com\$</code>	Regex whitelist ▾	Enabled	mtalk.google.com (andr
--	-------------------	---------	------------------------

2. Create a new group 'android' (web interface menu / Groups)

android	Enabled	android devices
---------	---------	-----------------

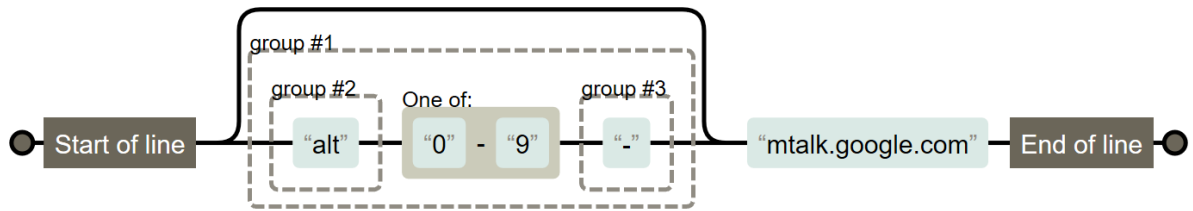
3. Add the android device (web interface menu / Clients), you've already imported (see the [clients](#) script) to the 'android' group. Ensure the devices are assigned to all the groups, e.g. if the 'android' group was the first you created, the entry will look like this (IP address and client name will differ), repeat this for all android devices:

192.168.2.170	s9	All selected (2) ▾
---------------	----	--------------------

4. Assign the domain entry to the android group. Ensure the domain (whitelist regex) is only assigned to the 'android' group (web interface menu / Domains).

<code>^((alt)[0-9](-))?mtalk\.google\.com\$</code>	Regex whitelist ▾	Enabled	mtalk.google.com (andr	android ▾
--	-------------------	---------	------------------------	-----------

All android devices will now receive a valid response, when requesting info for the mtalk.google.com domain and specific subdomains. The regex accomplishes the following (analyze a regex [here](#)):



Another example of selective whitelisting (whitelisted google ad links from the google search results) can be found in [this](#) document.

19. Group Management, duplicate blacklist and whitelist entries

Pi-hole allows you to create an identical blacklist AND whitelist entry.

An example: Assuming you want to block facebook, but allow access for a specific device (or devices).

The regular expression:

```
^(.+\..)?(facebook|fb(cdn|sbx)?|tfnw)\.(co\.)?[^.]+$
```

1. Create a blacklist regular expression for facebook and assign it to the default group, this will block facebook for all clients:

Domain/RegEx	Type	Status	Comment	Group assignment
^(.+\..)?(facebook fb(cdn sbx)? tfnw)\.(co\.)?[^.]+\$	Regex blacklist	Enabled	block facebook	Default

2. Create a group to allow access to facebook:

Name	Status	Description
Default	Enabled	The default group
AllowFacebook	Enabled	Allow Facebook

3. Add a client(s) to the group, assign the client to both the default and the AllowFacebook groups:

IP address	Comment	Group assignment
192.168.2.170 s9.localdomain	s9	All selected (2) ▾ Apply All None Default ✓ AllowFacebook ✓

4. Create the whitelist regular expression (identical to the blacklist regular expression) for facebook and assign it to the AllowFacebook group:

Domain/RegEx	Type	Status	Comment	Group assignment	Action
^(.+\.)?(facebook fb(cdn sbx)? tfbnw)\.(co o .)?[^\.]+\$	Regex whitelist ▾	Enabled	allow facebook	AllowFacebook ▾ Apply All None Default AllowFacebook ✓	🗑️

Done, facebook will now be accessible for the specific device(s) only, this because a **whitelist entry always wins**.

20. Windows DNS cache.

Enable/Disable pi-hole, using the pi-hole admin console, will not have an effect unless you change the windows DNS cache time permanently

To disable the Windows DNS cache:

Create a registry file with the following contents and add the info to the registry:

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\Dnscache\Parameters]
"MaxCacheTtl"=dword:00000001
```

Double click the file to add the setting to the registry.

To enable the Windows DNS cache:

Create a registry file with the following contents and add the info to the registry:

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\Dnscache\Parameters]
"MaxCacheTtl"=-
```

Double click the file to add the setting to the registry.

21. Changing the hostname.

If you have multiple pi's running, you might want to change the hostname, this to easily identify the host you're working on, using putty. Enter the following command:

```
sudo hostnamectl set-hostname <newhostname>
```

If you've installed [webmin](#), you may need to change an additional setting in the webmin configuration.

- Webmin / Webmin configuration / Sending Email:
 - o Requires [mail setup](#)!
 - o From address for email from Webmin:
 - Select **Address**
 - Enter the (g)mail address you used in the mail setup.

22. Protect your Raspberry Pi.

We've already enabled [key authentication](#), changed the [UNIX password](#) and [disabled password logon](#), we can however increase the security even more.

Depending upon you paranoia level, you can apply all security measures, described [here](#), however this document is limited to MITM attacks, spoof protection and disabling routing.

```
sudo nano /etc/sysctl.conf
```

Remove the comment sign from the lines below (red comment signs only)

```
# Uncomment the next two lines to enable Spoof protection (reverse-path filter)
# Turn on Source Address Verification in all interfaces to
# prevent some spoofing attacks
#net.ipv4.conf.default.rp_filter=1
#net.ipv4.conf.all.rp_filter=1

# Additional settings - these settings can improve the network
# security of the host and prevent against some network attacks
# including spoofing attacks and man in the middle attacks through
# redirection. Some network environments, however, require that these
# settings are disabled so review and enable them as needed.
#
# Do not accept ICMP redirects (prevent MITM attacks)
#net.ipv4.conf.all.accept_redirects = 0
#net.ipv6.conf.all.accept_redirects = 0

# Do not send ICMP redirects (we are not a router)
#net.ipv4.conf.all.send_redirects = 0

# Do not accept IP source route packets (we are not a router)
#net.ipv4.conf.all.accept_source_route = 0
#net.ipv6.conf.all.accept_source_route = 0
```

Reboot the Raspberry pi

```
sudo reboot
```

23. Disable unused hardware (Raspberry Pi® 3B, 3B+, 3A+, 4B and Zero W).

You may want to disable the WIFI interface and Bluetooth (reference [here](#)).

1. Disable WIFI.

```
echo "dtoverlay=disable-wifi" | sudo tee -a /boot/config.txt
```

2. Disable Bluetooth.

```
echo "dtoverlay=disable-bt" | sudo tee -a /boot/config.txt  
sudo systemctl disable hciuart
```

Reboot the Raspberry pi

```
sudo reboot
```

24. Using cron.

[cron](#) is installed by default on [Raspbian](#), no need to install additional packages. [Webmin](#), if installed, lists all cron jobs (system / scheduled cron jobs). Although many users prefer to use [crontab](#) to add cron jobs, jobs specified in `/etc/cron.d` are also processed, see the [man page](#) for details. I have been using this directory to add cron jobs, pi-hole development also uses this method (the pi-hole job - `/etc/cron.d/pihole`).

Some scripts in the github repository need to be executed regularly. Some examples:

1. Add new [NextDNS](#) entries (weekly).
Add the following file: `/etc/cron.d/NextDNS` (assuming your script is `/home/pi/NextDNS.sh`):

```
30 23 * * 6 root PATH="$PATH:/home/pi/" /home/pi/NextDNS.sh >/dev/null 2>&1
```

This script needs to run before the weekly gravity update, scheduled on Sunday, the above settings will run the script on Saturday at 23:30.

2. Run [needrestart](#) (daily).
Add the following file: `/etc/cron.d/needrestart` (assuming your script is `/home/pi/needrestart.sh`):

```
30 5 * * * root PATH="$PATH:/home/pi/" /home/pi/needrestart.sh >/dev/null 2>&1
```

This script will be executed daily at 05:30, it will send a mail (mail setup required) if user intervention is required.

- The redirection (`>/dev/null 2>&1`) ensures there will be no undesired emails, indicating the cron job has been executed. In order to troubleshoot cron jobs, remove the redirection temporarily.
- Make sure the cron instruction is terminated with a line feed, the instruction will not be processed without it.

25. Install some useful system tools

1. Install watchdog

Your system might get into trouble, by running a CPU hogging script, or a package that misbehaves. This might lead to an inaccessible (unresponsive) system, leaving you no choice, but to cut the power to regain access, **which might cause damage to your SD card**. Raspbian has a kernel module (`bcm2835_wdt`) that can help you avoid this drastic intervention.

Enable watchdog to send [mails](#), whenever triggered:

```
sudo ln -s /usr/bin/msmtp /usr/lib/sendmail
```

Example mail (high temperature):



raspberrypi.localdomain is going down!

Message from watchdog:

It is too hot to keep on working. The system will be halted!

Syslog entries:

```
watchdog[924]: temperature increases above 76 (/sys/class/thermal/thermal_zone0/temp)
watchdog[924]: temperature increases above 78 (/sys/class/thermal/thermal_zone0/temp)
watchdog[924]: temperature increases above 78 (/sys/class/thermal/thermal_zone0/temp)
watchdog[924]: it is too hot inside (temperature = 80 >= 80 for /sys/class/thermal/thermal_zone0/temp)
watchdog[924]: shutting down the system because of error 252 = 'too hot'
```

Install watchdog:

```
sudo apt-get -y install watchdog
```

Configure the watchdog

```
sudo nano /etc/watchdog.conf
```

Uncomment the following lines, don't uncomment "max-load-1", this may cause unexpected reboots!

```
max-load-5          = 18
max-load-15         = 12
watchdog-device      = /dev/watchdog
```

And add the following at the end of the file:

```
watchdog-timeout = 15
```

Reboot to start the watchdog with these settings:

```
sudo reboot
```

The watchdog will now be able to reboot your system, as soon as the load on the system is excessive. Normal load can be monitored on the pi-hole admin page (upper left corner) or by entering

```
uptime
```

2. Install schedtool

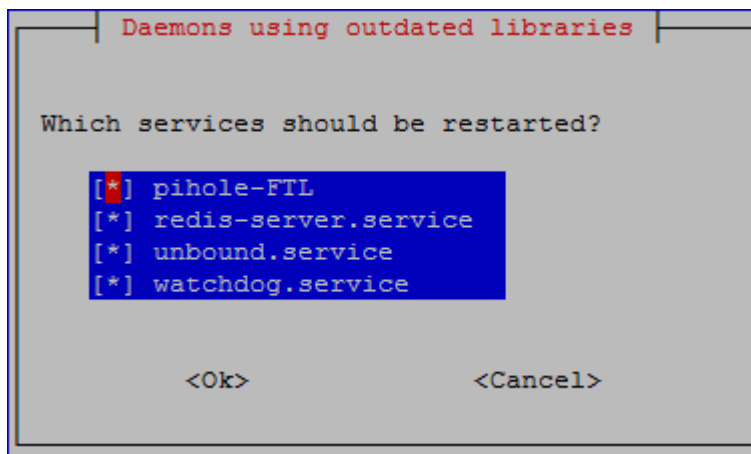
Some packages can use schedtool, to optimize the CPU use and cores. Install the package to allow CPU use optimization.

```
sudo apt-get -y install schedtool
```

3. Install needrestart.

If you installed and configured daily automatic updates, using [Webmin](#), your system will be kept up to date automatically, however Webmin doesn't restart daemons, still using the outdated libraries. The package needrestart allows you to determine which daemons need a restart. You will need to restart the daemon manually.

Needrestart integrates with apt-get, so running 'sudo apt-get -y upgrade' will automatically trigger the test. Webmin doesn't trigger needrestart, you will have to check it manually (sudo needrestart), or have a daily [cron job](#) and script to check it for you, and send you a mail (requires [mail setup](#)).



Installing needrestart:

```
sudo apt-get -y install needrestart
```

On a raspberry pi, some settings need to be modified in the configuration file, we don't want to test kernel updates and microcode updates, as these tests will generate false positives. Change the following settings in /etc/needrestart/needrestart.conf

```
$nrconf{kernelhints} = 0;  
$nrconf{ucodehints} = 0;
```

These settings are commented out (#) in the original configuration file (near the end of the file), uncomment and change the value where required.

To avoid having to check things manually, the following script will perform the required checks, and send you an email. Create a [cron job](#) to execute it daily.



Click on the icon to view the script in a browser. Copy the content and make the script executable (`sudo chmod +x /home/pi/needrestart.sh`). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

4. Helping the RANDOM number generator.

To avoid unexpected messages and warnings (you might see messages like 'System doesn't have enough entropy') whenever the system needs a random number, install rng-tools. As of the april 2019 version of raspbian, this package is already installed, you only need to modify the configuration file.

```
sudo apt-get -y install rng-tools
```

Edit the configuration file

```
sudo nano /etc/default/rng-tools-debian
```

Add the following line (**bold** only):

```
#HRNGDEVICE=/dev/hwrng  
#HRNGDEVICE=/dev/null  
HRNGDEVICE=/dev/urandom
```

26. IPv6 address.

If you are using the default [blocking mode](#), the value of the IPv6 address, registered by the pi-hole installation doesn't really matter, unless you use the address to browse to the admin web interface. If however, you are using a blocking mode where the IPv6 address is used, you may be confronted with the problem your ISP hands out IPv6 addresses that changes regularly. To overcome this problem (implies you have completed [mail setup](#)):

Create a script (`/home/pi/IPv6check.sh`) with the following content (you need to update '<your account name>'):



Click on the icon to view the script in a browser. Copy the content and make the script executable (`sudo chmod +x /home/pi/IPv6check.sh`). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

Using GUA: Replace the first few digits ('2a02' in my case) in the grep command to match your own!!!

Using LUA: Replace '2a02' in the grep command with 'fc|fd'

Make the script executable

```
sudo chmod +x /home/pi/IPv6check.sh
```

Create a [cron job](#) (/etc/cron.d/IPv6check) with the following content:

```
19 7 * * * root PATH="$PATH:/home/pi/" /home/pi/IPv6check.sh
```

Change the time to something appropriate for your system, the example runs at 07h19

27. Backup your pi-hole.

This procedure will only work, if you manually created a smaller Linux partition, explained in this [document](#). If you didn't reserve some free space, to allow for successful cloning, you probably will have to shrink the Linux partition first.

Once you have a working pi-hole, you can avoid setting it all up again by creating an image of your system.

Shutdown your system

```
sudo poweroff
```

Remove the SD card from the Raspberry Pi.

Use [Win32DiskImager](#) to create an image

- Insert the SD card into your computer.
- Start Win32DiskImager.
- Image File: Select a location and name for the image, e.g. C:\temp\pi-hole.img
- Device (source): Select the drive, holding the SD card, multiple partitions (drives) exist on the SD card, select the first one (all partitions will be processed).
- Select **Read**

Wait...

Use [Win32DiskImager](#) to write the image

- Insert the new (or used) SD card into your computer.
- Format the SD card, using [SDFormatter](#).
- Start Win32DiskImager.
- Image File: Select a location and name for the image, e.g. C:\temp\pi-hole.img
- Device (target): Select the drive, holding the SD card.
- Select **Write**

Wait...

Whenever you cloned (use [Win32DiskImager](#)) a backup image, the first thing you should do is set the date and time and restart the [NTP service](#). If you are using 'systemd-timesyncd.service', the systems default NTP service, this might be done automatically (never tested). If you have opted for the more robust NTP daemon, you need to do this manually, because the NTP daemon only allows for small time corrections, this to avoid large adjustments from an incorrect time source.

```
sudo /etc/init.d/ntp stop  
sudo ntpd -gq  
sudo /etc/init.d/ntp start
```

28. Customizing pi-hole (optional).

1. PHP info.

Pi-hole relies on PHP. If you want to add your own PHP scripts, you need to know how PHP is configured.

Create a file info.php in /var/www/html, content:

```
<?php  
phpinfo();  
?>
```

To view the PHP info, browse to:

```
http://<your Raspberry pi's static address>/info.php
```

2. Lighttpd Server Status.

The default web server (lighttpd) has a status page, however, it isn't activated with a default pi-hole installation.

Reference: https://redmine.lighttpd.net/projects/1/wiki/Docs_ModStatus

To enable this page, run the following script (/home/pi/lighttpdstatus.sh):



Click on the icon to view the script in a browser. Copy the content and make the script executable (sudo chmod +x /home/pi/lighttpdstatus.sh). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

Make the script executable:

```
sudo chmod +x /home/pi/lighttpdstatus.sh
```

Unfortunately, this configuration will be lost, as soon as you upgrade (pihole -up) or reconfigure (pihole -r) your system. Simply run the script again, the script will add the missing entries.

Run the script, assuming the current directory is /home/pi.

```
sudo ./lighttpdstatus.sh
```

To view the Server status, browse to:

```
http://<your Raspberry pi's static address>/server-status?refresh=15
```

3. Browsing the FTL database.

The FTL database is a [sqlite3](#) database, it contains the data, required to populate pi-hole's admin website.

Reference: <https://www.phpliteadmin.org/download/>

You can browse this database by installing phpLiteAdmin. To enable this, run the following script (/home/pi/phpliteadmin.sh):



Click on the icon to view the script in a browser. Copy the content and make the script executable (sudo chmod +x /home/pi/ phpliteadmin.sh). You can also use [wget](#) (click on Basic usage) to copy the script directly. Execute the script with 'sudo'!

Make the script executable:

```
sudo chmod +x phpliteadmin.sh
```

Run the script, assuming the current directory is /home/pi

```
sudo ./phpliteadmin.sh
```

To access the database (password: '**admin**'), browse to:

```
http://<your Raspberry pi's static address>/phpliteadmin.php
```

Information regarding the content of the database can be found [here](#).

The database will be accessible in read-only mode, you cannot make any changes. To make the database writable, execute the following commands:

```
# Write permissions on the Database
sudo usermod -a -G pi-hole www-data
sudo chmod 775 /etc/pihole
sudo chmod 664 /etc/pihole/pihole-FTL.db
sudo chmod 664 /etc/pihole/gravity.db
sudo service lighttpd stop
sudo service lighttpd start
```

Useful chromium extension [here](#) (Epoch Convertor by drautb, converts Unix timestamp to date & time). Example:

← T →	id	timestamp	type	status	domain	client
	723150	1655624859	1	2	ds.download.windowsupdate.com	192.168.2.2
	723151	1655624859	1	2	ds.download.windowsupdate.com	192.168.2.2
		06/19/2022 - 09:47:39		1	userlocation.googleapis.com	192.168.2.1
				1	ssl.google-analytics.com	192.168.2.1
	723154	1655624901	1	2	fe2.update.microsoft.com	192.168.2.2
	723155	1655624901	1	2	fe2.update.microsoft.com	192.168.2.2

29. DoT / DoH

Pi-hole will only filter DNS requests, if your devices use pi-hole as their only DNS server. Some devices (example Chromecast), use a hard coded DNS server (example [8.8.8.8](#)), the DNS requests from these devices will never be processed by pi-hole. To overcome this, it is necessary to implement a firewall rule, that redirects all DNS requests ([port 53](#)), **not originating from pi-hole**, to pi-hole.

Pi-hole cannot be used to filter DoT ([DNS over TLS](#)) requests, the DoT request will have a DOT server as destination, thus bypassing pi-hole. Fortunately, it's easy to block DoT requests on your network, by implementing a firewall rule that blocks [port 853](#), thus effectively killing DoT.

Pi-hole cannot be used to filter DoH ([DNS over HTTPS](#)) requests, the DoH request will have a DoH server as destination, thus bypassing pi-hole. DoH cannot be easily blocked, because it uses [port 443](#), which happens to be the same port, used for HTTPS.

Unfortunately, some applications have implemented DoH capability, thus allowing the application to completely ignore the systems DNS settings. Those applications will thus bypass pi-hole, and have unfiltered access to the internet.

Pi-hole implemented a way to [prevent Firefox from using DoH](#), by ensuring the domain use-application-dns.net ([canary domain](#)) is resolved as an NXDOMAIN, thus informing Firefox to use the DNS system settings.

Pi-hole also implemented a way to warn the user he should use a specific network without using a [Private Relay](#) (icloud private Relay, the apple version of [oDoH](#)).

You can read more about this [here](#) (scroll down to section 6 – Network control, using DNS entries).

Other applications however, do not have a straight forward (or none at all) method, to ensure they don't use DoH. The only way to prevent these applications from using DoH, is to ensure the DoH destination server cannot be reached. There are a number of sites that list information, regarding existing DoH servers. Available to you now, compiled from several sources, updated daily, are two lists ([DOHipv4.txt](#) and [DOHipv6.txt](#)), you can use to implement a firewall rule, blocking port 443 for the destinations in the list. **You must ensure to block only port 443** for these IP's, the list contains the IP's for servers that reply to both port 443 and port 53, blocking all access to these IP's could possibly break pi-hole.

Unfortunately, some of the IP addresses in the above lists, cannot be blocked, as the IP is the destination for both DoH and content. For example, the DoH server dns.cloudflare.com has the same IP(s) as cdnjs.cloudflare.com, the later is used to serve some scripts, used by several by several websites, such as [linuxquestions.org](#). If the IP for dns.cloudflare.com (DoH) is blocked, the webpage will load extremely slow, as it cannot load the required content. To overcome this, two additional lists ([DOHexceptionsIPv4.txt](#) and

[DOHexceptionsIPv6.txt](#)) are provided. The idea here is to create exceptions (allow) these addresses for **specific devices only**.

In order to use the list(s), you will need to create a Firewall [URL Table Alias](#) and a firewall rule that blocks port 443 for the DoH server destinations, using the alias. **This will NOT be possible on all firewalls**, check your firewalls documentation.

A method to setup the required aliases and rules on [pfsense](#), is described in this [document](#).

The [GitHub](#) repository provides the (o)DoH domain [list](#) in rpz format, which eliminates the need to generate a pi-hole compatible list from the [database](#), see the [unbound](#) section for details.

30. Using unbound as upstream resolver.

In order to increase DNS privacy, many pi-hole users use [unbound](#) as upstream resolver. Basic unbound installation instructions, as recommended by the pi-hole developers, can be found [here](#). Unbound has a lot of configuration options, most of them explained [here](#). Optimizing the performance of unbound can be achieved, using these [guidelines](#).

Unbound v1.10.0 allows the use of [response policy zones](#) (rpz), however, v1.14.0 has added a lot of configuration options, v1.14.1 does allow pi-hole to detect (query log) domains, blocked by the unbound rpz configuration. This will allow you to block domains without the option to whitelist, even when pi-hole is temporarily disabled. Unbound automatically downloads and updates these zones, using the settings in the SOA record (part of the [rpz file](#)). You can find more on this (how to setup) in this [document](#).

31. Change Log

06-09-2019

- Updated version of [phpliteadmin](#) (v1.9.8.2) requires php-mbstring to be installed.

30-09-2019

- Added download link for MD5 & SHA Checksum utility.

22-11-2020

- Added backup / restore (clone) instructions.

05-03-2021

- Added AdguardTeam CNAME script.

01-09-2021

- Added "changing the hostname" section
- Added "install needrestart" section.

23-01-2022

- Added note to reschedule [webmin](#) scheduled updates (recommended for [needrestart](#))
- Removed the [shallalist](#) script, service has been terminated.
- Added [quidsup](#) script, includes instructions to use local pi-hole compatible lists.
- Added [cron](#) section, with examples.
- Added [unbound](#) section.

13-02-2022

- The package [sqlite3](#) is no longer installed during the installation. Sqlite3 is now embedded in pihole-FTL (read [here](#)). All scripts and references have been updated to reflect this change.

08-06-2022

Gmail changed the [policy](#) for less secure apps, you need to use an [app password](#) in your [mail](#) configuration.

19-06-2022

- Added link to useful chromium (chrome / edge) extension (Epoch Convertor), when using [phpLiteAdmin](#).

15-01-2023

- Major changes in the lighttpd configuration:
 - /etc/lighttpd/external.conf is no longer included, you need to use an alternate method to specify additional lighttpd configuration items.
 - fastcgi-php is no longer enabled, implies php scripts will generate error 403.

Look at the [Lighttpd Server Status script](#) to learn how to fix the problem.

10-02-2023

- [Pi-hole core v5.15.5](#), [Pi-hole web v5.18.4](#), [Pi-hole-FTL v5.21](#) released.

24-02-2023

- Raspberry Pi OS Lite [February 21st 2023](#) released. **Warning:** no default user/password anymore, for headless setup, read this [topic](#)

13-03-2023

- Webmin 2.020 released.