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B. Acknowledgments / Contributions
This project is the result of years of work by many individuals and companies. Many people have written or tweaked the software; the drivers, clients, server and documentation have all received valuable attention from numerous sources. Many of them are listed within the source code, AUTHORS file, release notes, and mailing list archives, but some prefer to be anonymous. This software would not be possible without their help.

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The source file for this document has been marked up by the editor in \LaTeX and rendered as PDF file ConfigExamples.A5.pdf in a portrait A5 format, 131 pages with one page per sheet. Your PDF viewer may be able to place two pages side by side on your big monitor.

The document is not only linear reading, but also hypertext. All chapters in the table of contents, all chapter references, all line number references throughout the document, all man page names and URL’s are clickable. Such links are outlined in colour, for example man ups.conf If your mouse hovers over a clickable surface, your browser/PDF reader may tell you where the link leads.
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Changes:

- 2017-06-27 First edition
- 2017-08-10 Added appendix D, “Using notify-send”.
- 2018-08-22 In chapter 3.1 added reference to issue #597 for multiple UPS units.
- 2019-07-21 Added chapter 11 “Encrypted connections”.
- 2020-08-20 File heartbeat.dev becomes heartbeat.conf
- 2020-09-30 Added Part 2 covering the Python3 scripts. Deprecated Part 3 “Encrypted connections”.
- 2021-05-16 Split Part 2 into two parts: new Part 2 for the shim daemons, and a new part 3 for the Python3 replacement for upsmon and upssched. The Appendix becomes Part 4.
- 2021-06-06 Migrated figures from xfig to inkscape.
- 2021-08-03 Clarified that command upsmon -c fsd calls the command specified by declaration SHUTDOWNCMD.
- 2023-01-02 Passwords should not contain spaces or quotation marks ".
- 2023-01-04
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Part 1

UPS monitoring using NUT

The first part of this documentation discusses UPS activity monitoring using the facilities provided by NUT 2.8.0. Part 2 discusses TLS support for upsd and the clients. Part 3 provides technical appendices.

1 Introduction, and Welcome to NUT

1.1 What is NUT?

The acronym NUT stands for “Network UPS Tools”. It is a collection of GPL licensed software written in K&R style C for managing power devices, mainly UPS units. It supports a wide range of UPS units and can handle one or multiple UPS's of different models and manufacturers simultaneously in home, small business and larger professional installations. NUT replaces the software which came with your UPS.

The NUT software is included as a package in most major distributions of Linux, and the source code is available in a tarball for the others.

The NUT software includes complete technical documentation in the form of PDF manuals, configuration notes such as file config-notes.txt man pages, a web site http://networkupstools.org and detailed comments in the sample configuration files supplied with the project. There is also a FAQ on the project web site, and a nut-upsuser mailing list in which users may ask questions.
1.1.1  NUT is a mature project

NUT was already operating in its current form when it registered port 3493/TCP (nut) with IANA in May 2002. Since then, the project has kept its principal characteristics which are the basis of its success:

- **Simplicity** – The design of NUT is simple and straightforward. No additional tools or software systems are needed to encode the messages sent between the attachment daemon and the management daemon.

- **Resilience** – The ability to operate in a *challenged environment*. Such environments are now receiving attention, for example the evolving vocabulary provided by [RFC 7228](https://tools.ietf.org/html/rfc7228) Terminology for Constrained-Node Networks.

- **Aggregation** – The simultaneous handling of a wide variety of UPS-things with widely differing capabilities. This is now known as the “Internet of Things”, and again is the subject of much attention.

1.2  You need to configure the NUT software

To make full use of your UPS you will need to configure the NUT software used to manage UPS units. The technically complete documentation does not provide many examples; this introduction is intended to fill the gap by providing fully worked examples for some frequently met configurations. It is aimed at experienced Unix/Linux system administrators who are new to NUT. Pick the configuration which corresponds most closely to your installation, get it working, and then adapt it to your needs. If you have questions for the mailing list it is much easier to explain what you are trying to do by referring to a well known example.

1.3  Attachment Daemon upsd

Figure 1 shows the basic components of the NUT software. `upsd` is a daemon which runs permanently in the box to which one or more UPS's are attached. It scans the UPS's through the UPS-specific driver[^1] and maintains an abstracted image of the UPS in memory[^2].

The various parts of the abstracted image have standardized names, and a key part is the variable `ups.status` which gives the current status of the UPS unit. The current status is a string of symbols. The principal symbols are shown in figure 2[^1] but if you write software which processes `upsd` symbols, expect to find other values in exceptional UPS specific cases.

Some important status values are `OL` which means that the UPS unit is taking power from the wall, and `OB LB` which means that wall power has failed, the UPS is supplying power from it’s battery, and that battery is almost exhausted.

[^1]: See the Hardware Compatibility list and required drivers at [https://www.networkupstools.org/stable-hcl.html](https://www.networkupstools.org/stable-hcl.html)
[^2]: This image may be viewed at any time with the command `upsd` `name-of-UPS`
Daemon `upsd` listens on port `3493/tcp` (nut) for requests from its clients, which may be local or remote. It is amusing to test this using a tool such as `nc` or `netcat` and a UPS called **UPS-1**.

```bash
1  rprice@maria:~> REQUEST="GET VAR UPS-1 battery.charge"
2  rprice@maria:~> echo $REQUEST | nc localhost 3493
3  VAR UPS-1 battery.charge "100"
```

Chapter 1.4.1 will show that this is best done with NUT utility program `upsc`.

Later chapters will discuss the configuration files **ups.conf**, `upsd.conf` and `upsd.users` with the specific examples. For gory details, read `man upsd`, `man upsd.conf`, `man upsd.users` and `man ups.conf`.

| OL | UPS unit is receiving power from the wall. |
| OB | UPS unit is not receiving power from the wall and is using its own battery to power the protected device. |
| LB | The battery charge is below a critical level specified by the variable `battery.charge.low`. |
| RB | UPS battery needs replacing. |
| CHRG | The UPS battery is currently being charged. |
| DISCHRG | The UPS battery is not being charged and is discharging. |
| ALARM | An alarm situation has been detected in the UPS unit. |
| OVER | The UPS unit is overloaded. |
| TRIM | The UPS voltage trimming is in operation. |
| BOOST | The UPS voltage boosting is in operation. |
| BYPASS | The UPS unit is in bypass mode. |
| OFF | The UPS unit is off. |
| CAL | The UPS unit is being calibrated. |
| TEST | UPS test in progress. |
| FSD | Tell secondary `upsmon` instances that final shutdown is underway. |

Figure 2: Symbols used in **ups.status** maintained by `upsd`. 
1.3.1 Driver daemon

The driver is a daemon which is part of the attachment daemon\textsuperscript{3}. It talks to the UPS hardware and is aware of the state of the UPS. One of the strengths of the NUT project is that it provides drivers for a wide range of UPS units from a range of manufacturers. NUT groups the UPS’s into families with similar interfaces, and supports the families with drivers which match the manufacturer’s interface. See the hardware compatibility list for a long list of the available drivers.

The drivers share a command interface, upsdrvctl, which makes it possible to send a command to the UPS without having to know the details of the UPS protocol. We will see this command in action in chapter 2.5 when we need to shut down the UPS after a system shutdown.

1.4 Management Daemon upsmon

The management daemon upsmon is an example of a client of upsd. It runs permanently as a daemon in a local or remote box, polling the status changes of the UPS unit. It is able to react to changes in the UPS state for example by emitting warning messages, or shutting down the box. The actions are specified in the configuration file upsmon.conf which will be discussed in specific examples.

As the state of a UPS evolves, the key status changes, called “NOTIFY events”, are identified with the symbols shown in figure 4. The NOTIFY event symbol is also known as a “notifytype” in NUT.

Figure 3 shows what happens when wall power fails. Daemon upsd has polled the UPS, and has discovered that the UPS is supplying power from it’s battery. The ups.status changes to [OB].

\textsuperscript{3}Communication between upsd and each driver is through a socket which Debian 11 declares in directory /\texttt{var/run/nut}. The following example shows the sockets to two drivers usbhid-ups and dummy-ups:

```bash
root@titan ls -alF /run/nut
drwxrwx-- 2 root nut 140 Aug 7 15:57 .
drwxr-xr-x 30 root root 880 Aug 7 16:01 ..
srw-rw-- 1 nut nut 0 Aug 7 15:57 dummy-ups-heartbeat=
-rw-r--r- 1 nut nut 5 Aug 7 15:57 dummy-ups-heartbeat.pid
-rw-r--r- 1 nut nut 5 Aug 7 15:57 upsd.pid
srw-rw-- 1 nut nut 0 Aug 7 15:57 usbhid-ups-Eaton=
-rw-r--r- 1 nut nut 4 Aug 7 15:57 usbhid-ups-Eaton.pid
```
NOTIFY events based on status changes

<table>
<thead>
<tr>
<th>ONLINE</th>
<th>Status change $\text{OB} \rightarrow \text{OL}$. The UPS is back on line.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONBATT</td>
<td>Status change $\text{OL} \rightarrow \text{OB}$. The UPS is now on battery.</td>
</tr>
<tr>
<td>LOWBATT</td>
<td>Status $\text{LB}$ has appeared. The driver says the UPS battery is low.</td>
</tr>
<tr>
<td>REPLBATT</td>
<td>The UPS needs to have its battery replaced. Not all UPS’s can indicate this.</td>
</tr>
</tbody>
</table>

NOTIFY events based on upsmon activity

<table>
<thead>
<tr>
<th>FSD</th>
<th>No status change. The primary has commanded the UPS into the “forced shutdown” mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHUTDOWN</td>
<td>The local system is being shut down.</td>
</tr>
<tr>
<td>COMMOK</td>
<td>Communication with the UPS has been established.</td>
</tr>
<tr>
<td>COMMBAD</td>
<td>Communication with the UPS was just lost.</td>
</tr>
<tr>
<td>NOCOMM</td>
<td>The UPS can’t be contacted for monitoring.</td>
</tr>
</tbody>
</table>

NOTIFY event based on NUT process error

| NOPARENT | upsmon parent died - shutdown impossible. |

Figure 4: Symbols used to represent NOTIFY events maintained by upsmon.

Daemon upsmon has polled ups, has discovered the status change and has generated the NOTIFY event [ONBATT].

For the gory details, read `man upsmon` and `man upsmon.conf`.

1.4.1 Utility program upsc

The NUT project provides this simple utility program to talk to ups and retrieve details of the UPS’s. For example, “What UPS’s are attached to the local host?”

```bash
rprice@maria:~> upsc -L
UPS-1: Example Mfg ASR 1500 USBS
heartbeat: Heart beat validation of NUT
```

Let’s ask for the ups abstracted image of a UPS:

```bash
rprice@maria:~> upsc UPS-1
battery.charge: 100
battery.charge.low: 50
... 
driver.name: usbhid-ups
driver.parameter.offdelay: 30
driver.parameter.ondelay: 40
... 
ups.status: OL CHRG
```
Let’s ask, using Bash syntax, for a list of the drivers used by `upsd`:

```
16 rprice@maria:~> for u in $(upsc -l)
17 > do upsc $u driver.name
18 > done
19 ushbid-ups
20 dummy-ups
```

Man page `man upsc` provides further examples.

### 1.5 Configuration file formats

The components of NUT get their configuration from the following configuration files. The simpler configurations do not use all these files.

- **nut.conf**     Nut daemons to be started.
- **ups.conf**     Declare the UPS’s to be managed by `upsd`.
- **heartbeat.conf** Used only for `heartbeat` configurations.
- **upsd.conf**    Access control to the `upsd` daemon.
- **upsd.users**   Who has access to the `upsd` daemon.
- **upsmon.conf**  `upsmon` daemon configuration.
- **upssched.conf** Only used for customised and timer-based setups.
- **upssched-cmd** A script used only for customised and timer-based setups.
- **delayed UPS shutdown** Choice of scripts for delayed UPS shutdown.

NUT parses all the configuration files with a common state machine, which means they all have the following characteristics.

First, most of the programs use an uppercase word to declare a configuration directive. This may be something like `MONITOR`, `NOTIFYCMD`, or `ACCESS`. Case matters here. “monitor” won’t be recognized.

Next, the parser does not care about whitespace between words. If you like to indent things with tabs or spaces, feel free to do so.

The keywords are often followed by values. If you need to set a value to something containing spaces, it has to be contained within “quotes” to keep the parser from splitting the line, e.g.

```
21 SHUTDOWNCMD "/sbin/shutdown -h +0"
```

Without the quotes, the parser would only see the first word on the line. Let’s say you really need to embed a quote within your directive for some reason. You can do that too.

```
22 NOTIFYCMD "/bin/notifyme -foo -bar "hi there" -baz"
```
In other words, \ can be used to escape the ".
When you need to put the \ character into your string, you just escape it.

23 \texttt{\texttt{NOTIFYCMD "/bin/notifyme c:\dos\style\path"}}

The \ can be used to escape any character, but you only really need it for \, ", and # as they have special meanings to the parser.
When using file names with space characters, you may end up having tricky things since you need to write them inside "" which must be escaped:

24 \texttt{\texttt{NOTIFYCMD "\"c:\path with space\notifyme\""}}

# is the comment character. Anything after an unescaped # is ignored, e.g.

25 \texttt{\texttt{identity = my\#1ups}}

will turn into \texttt{identity = my}, since the # stops the parsing. If you really need to have a # in your configuration, then escape it.

26 \texttt{\texttt{identity = my\#1ups}}

Much better.
The = character should be used with care too. There should be only one “simple” = character in a line: between the parameter name and its value. All other = characters should be either escaped or within “quotes”. Remember that the # character in a password must be escaped:

27 \texttt{\texttt{password = 12=34#56 \hspace{1cm} Incorrect}}
28 \texttt{\texttt{password = 12\=34\#56 \hspace{1cm} Good}}
29 \texttt{\texttt{password = NUT=Awesome \hspace{1cm} Incorrect}}
30 \texttt{\texttt{password = "NUT=Awesome" \hspace{1cm} Good}}

\subsection{Line spanning}

You can put a backslash at the end of the line to join it to the next one. This creates one virtual line that is composed of more than one physical line.

Also, if you leave the "" quote container open before a newline, it will keep scanning until it reaches another one. If you see bizarre behavior in your configuration files, check for an unintentional instance of quotes spanning multiple lines.
1.6 Mailing list: nut-users

The NUT project offers a mailing list to assist the users. The web page for list administration is https://lists.alioth.debian.org/mailman/listinfo/nut-users.

As always in mailing lists, you get better results if you remember Eric Raymond’s good advice which you will find in “How To Ask Questions The Smart Way” at http://www.catb.org/esr/faqs/smart-questions.html.

The NUT mailing lists accept HTML formatted e-mails, but it’s better to get into the habit of sending only plain text, since you will meet mailing lists that send HTML to /dev/null.

If you want to quote configuration files, please remove comments and blank lines. A command such as grep ^[^#] upsmon.conf will do the job. To save you some work, there is ready-made script to prepare a report on a NUT configuration. See nut-report script available at http://rogerprice.org/NUT/nut-report.

1.7 NUT has an RFC

On August 8th, 2022, the IETF published RFC 9271 Uninterruptible Power Supply (UPS) Management Protocol – Commands and Responses which describes in detail the commands and responses of the NUT protocol. The RFC follows changes in the technical terms used by the NUT Project and listed in figure 5.

<table>
<thead>
<tr>
<th>Term used up to NUT 2.7.4</th>
<th>Term used in NUT 2.8.0, RFC 9271 and this document</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALREADY-LOGGED-IN</td>
<td>ALREADY-ATTACHED</td>
</tr>
<tr>
<td>ALREADY-SSL-MODE</td>
<td>TLS-ALREADY-ENABLED</td>
</tr>
<tr>
<td>LOGIN</td>
<td>ATTACH</td>
</tr>
<tr>
<td>LOGOUT</td>
<td>DETACH</td>
</tr>
<tr>
<td>Master</td>
<td>Primary</td>
</tr>
<tr>
<td>Slave</td>
<td>Secondary</td>
</tr>
<tr>
<td>NETVER</td>
<td>PROTVER</td>
</tr>
<tr>
<td>NUMLOGINS</td>
<td>NUMATTACH</td>
</tr>
</tbody>
</table>

Figure 5: NUT terms changed by NUT 2.8.0 and the RFC.

The RFC uses the term “public power supply” where this text refers to “wall power”.

Now that we have the basic ideas of NUT, we are ready to look at the first simple configuration.
2 Simple server with no local users

This chapter extends the general ideas of chapter [1] to provide a fully worked example of a simple configuration. This will in turn form the basis of future chapters. In this simple configuration, the attachment daemon and the management daemon run in the same machine.

Six configuration files specify the operation of NUT in the simple server.

1. The NUT startup configuration: nut.conf. Since this file is not strictly a part of NUT, and is common to all configurations, it is discussed separately in appendix A.
2. The upsd UPS declarations: ups.conf, see chapter 2.1.
3. The upsd daemon access control; upsd.conf, see chapter 2.2.
4. The upsd daemon user declarations: upsd.users, see chapter 2.3.
5. The upsmon daemon configuration: upsmon.conf, see chapter 2.4.
6. The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix B.

2.1 Configuration file ups.conf, first attempt

This configuration file declares your UPS units. The file described here will do the job, but we will see after we have discussed the shutdown process, that useful improvements are possible.

Line 32 begins a UPS-specific section, and names the UPS unit UPS-1. There will as many sections as there are UPS units. Make sure this UPS name matches the name in upsmon.conf and in upssched-cmd, which we will meet in later chapters.

```
# ups.conf, first attempt
[UPS-1]
driver = usbhid-ups
port = auto
desc = "Example Mfg 1600"
```

Figure 7: Configuration file ups.conf, first attempt.
Line 33 specifies the driver that upsd will use. For the full list of drivers, see the Hardware Compatibility list and the required drivers at http://www.networkupstools.org/stable-hcl.html.

Line 34 depends on the driver. For the usbhid-ups driver the value is always auto. For other drivers, see the man page for that driver.

Line 35 provides a descriptive text for the UPS.

### 2.2 Configuration file upsd.conf

```plaintext
# upsd.conf
LISTEN 127.0.0.1 3493
LISTEN ::1 3493
```

Figure 8: Configuration file upsd.conf.

This configuration file declares on which ports the upsd daemon will listen, and provides a basic access control mechanism.

Line 37 declares that upsd is to listen on its preferred port for traffic from the localhost. The IP address specifies the interface on which the upsd daemon will listen. The default 127.0.0.1 specifies the loopback interface. It is possible to replace 127.0.0.1 by 0.0.0.0 which says “listen for traffic from all sources” and use your firewall to filter traffic to port 3493. For good security, this file should be accessible to the upsd process only.

If you do not have IPv6, remove or comment out line 38.

### 2.3 Configuration file upsd.users

```plaintext
# upsd.users
[nut-admin]
    password = sekret
    upsmmon primary
```

Figure 9: Configuration file upsd.users for a simple server.

This configuration file declares who has write access to the UPS. For good security, ensure that only users nut and root can read and write this file.

Line 40 declares the “user name” of the system administrator who has write access to the UPS’s managed by upsd. It is independent of /etc/passwd. The upsmmon client daemon will use this name to poll and command the UPS’s. There may be several names with different levels of access. For this example we only need one.

Line 41 provides the password. You may prefer something better than “sekret”. **Warning:** Avoid placing spaces U+0020 and quotation marks " U+0022 in passwords.

Line 42 declares that this user is the upsmmon daemon, and the required set of actions will be set automatically. In this simple configuration daemon upsmmon is a primary and has authority to shutdown the server. The alternative, “upsmmon secondary”, allows monitoring only, with no shutdown authority.

The configuration file for upsmmon must match these declarations for upsmmon to operate correctly. For lots of details, see man upsd.users

---

4 This is for Debian 11. See table 104 in appendix C for other user names.
5 Up to NUT 2.7.4 the primary was known as the “master”. The secondary was known as the “slave”.

Page 10 of 131
2.4 Configuration file \texttt{upsmon.conf} for a simple server

This configuration file declares how \texttt{upsmon} is to handle NOTIFY events. For good security, ensure that only users \texttt{nut} and root can read and write this file.

```
# upsmon.conf
MONITOR UPS-1@localhost 1 nut-admin sekret primary
```

Figure 10: Configuration file \texttt{upsmon.conf} for a simple server, part 1 of 5.

On line 44:
- The UPS name \texttt{UPS-1} must correspond to that declared in \texttt{ups.conf} line 32.
- The “power value” 1 is the number of power supplies that this UPS feeds on this system.
- \texttt{nut-admin} is the “user” declared in \texttt{upsd.users} line 40.
- \texttt{sekret} is the password declared in \texttt{upsd.users} line 41.
- \texttt{primary} means this system will shutdown last, allowing any secondaries time to shutdown first. Secondary systems will be discussed in chapter 5. There are no secondaries in this simple configuration.

```
SHUTDOWNCMD "/sbin/shutdown -h +0"
POWERDOWNFLAG /etc/killpower
```

Figure 11: Configuration file \texttt{upsmon.conf} for a simple server, part 2 of 5.

Line 45 declares the command that is to be used to shut down the server. A second instance of the \texttt{upsmon} daemon running as root will execute this command. Multiple commands are possible, for example \texttt{SHUTDOWNCMD "logger -t upsmon.conf \"SHUTDOWNCMD calling /sbin/shutdown to shut down system\" ; /sbin/shutdown -h +0"} will also log the action of \texttt{SHUTDOWNCMD}. Note that internal " have to be escaped.

Line 46 declares a file created by \texttt{upsmon} when running in primary mode when the UPS needs to be powered off. It will be used in more complex configurations. See \texttt{man upsmon.conf} for details.

Lines 47-56 assign a text message to each NOTIFY event. Within each message, the marker \texttt{\%s} is replaced by the name of the UPS which has produced this event. \texttt{upsmon} passes this message to program \texttt{wall} to notify the system administrator of the event. You can change the default messages to something else if you like. The format is \texttt{NOTIFYMSG event "message"} where \texttt{\%s} is replaced with the identifier of the UPS in question.

Lines 57-66 declare what is to be done at each NOTIFY event. The declarations, known as “flags” are shown in table 14. You may specify one, two or three flags for each event, in the form \texttt{FLAG[+FLAG]*}, however \texttt{IGNORE} must always be alone.

Note that if you have multiple UPS’s, the same actions are to be performed for a given NOTIFY event for all the UPS’s. \texttt{We will see later that this is not good news.}

\footnote{This is for Debian 11. See table 104 in appendix C for other user names.}
Figure 12: Configuration file `upsmon.conf` for a simple server, part 3 of 5.

```
47 NOTIFYMSG ONLINE "UPS %s: On line power."
48 NOTIFYMSG ONBATT "UPS %s: On battery."
49 NOTIFYMSG LOWBATT "UPS %s: Battery is low."
50 NOTIFYMSG REPLBATT "UPS %s: Battery needs to be replaced."
51 NOTIFYMSG FSD "UPS %s: Forced shutdown in progress."
52 NOTIFYMSG SHUTDOWN "Auto logout and shutdown proceeding."
53 NOTIFYMSG COMMOK "UPS %s: Communications (re-)established."
54 NOTIFYMSG COMMBAD "UPS %s: Communications lost."
55 NOTIFYMSG NOCOMM "UPS %s: Not available."
56 NOTIFYMSG NOPARENT "upsmon parent dead, shutdown impossible."
```

Figure 13: Configuration file `upsmon.conf` for a simple server, part 4 of 5.

```
57 NOTIFYFLAG ONLINE SYSLOG+WALL
58 NOTIFYFLAG ONBATT SYSLOG+WALL
59 NOTIFYFLAG LOWBATT SYSLOG+WALL
60 NOTIFYFLAG REPLBATT SYSLOG+WALL
61 NOTIFYFLAG FSD SYSLOG+WALL
62 NOTIFYFLAG SHUTDOWN SYSLOG+WALL
63 NOTIFYFLAG COMMOK SYSLOG+WALL
64 NOTIFYFLAG COMMBAD SYSLOG+WALL
65 NOTIFYFLAG NOCOMM SYSLOG+WALL
66 NOTIFYFLAG NOPARENT SYSLOG+WALL
```

Figure 14: Flags declaring what `upsmon` is to do for NOTIFY events.

<table>
<thead>
<tr>
<th>IGNORE</th>
<th>Don’t do anything. Must be the only flag on the line.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSLOG</td>
<td>Write the message in the system log.</td>
</tr>
<tr>
<td>WALL</td>
<td>Use program <code>wall</code> to send message to terminal users. Note that <code>wall</code> does not support accented letters or non-latin characters.</td>
</tr>
<tr>
<td>EXEC</td>
<td><em>(Not used for this simple server example).</em></td>
</tr>
</tbody>
</table>

Figure 15: Configuration file `upsmon.conf` for a simple server, part 5 of 5.

```
67 RBWARNTIME 43200
68 NOCOMMWARNTIME 300
69 FINALDELAY 5
```

Figure 15: Configuration file `upsmon.conf` for a simple server, part 5 of 5.

When a UPS says that it needs to have its battery replaced, `upsmon` will generate a `[REPLBATT]` NOTIFY event. Line 67 say that this happens every `RBWARNTIME = 43200` seconds (12 hours).
Line 68: Daemon `upsmon` will trigger a `[NOCOMM]` NOTIFY event after `NOCOMMWARNTIME` seconds if it can’t reach any of the UPS entries in configuration file `upsmon.conf`. It keeps warning you until the situation is fixed.

Line 69: When running in primary mode, `upsmon` waits this long after sending the `[SHUTDOWN]` NOTIFY event to warn the users. After the timer elapses, it then runs your `SHUTDOWN CMD` as specified on line 45. If you need to let your users do something in between those events, increase this number. Remember, at this point your UPS battery is almost depleted, so don’t make this too big. Alternatively, you can set this very low so you don’t wait around when it’s time to shut down. Some UPS’s don’t give much warning for low battery and will require a value of 0 here for a safe shutdown.

For lots and lots of details, see `man upsmon.conf` See also the file `config-notes.txt` in the distribution.
### 2.5 The delayed UPS shutdown

Somewhere in your distribution, as part of the system shutdown process, there needs to be an action to send a message to the UPS to tell it that some time later, it too will shut down. Note that the UPS does not shutdown at the same time as the system it protects. The UPS shutdown is **delayed**. By default the delay is 20 seconds. We will see in a later chapter how to change this. (Line 77 if you’re curious.)

The delayed UPS shutdown command may be from a shell script or a systemd service unit but in all cases the key element is the command `upsdrvctl shutdown`. Figure 17 shows the shell script supplied by NUT to be placed in a systemd “drop-in” directory for scripts which should be executed as late as possible during a system shutdown. This script is used by openSUSE and Debian 11 and is placed in file `/usr/lib/systemd/system-shutdown/nutshutdown`. systemd detects automatically that a script in one of these “drop-in” directories needs to be executed. There is no need to enable the script.

```bash
#!/bin/sh
/usr/sbin/upsmon -K >/dev/null 2>&1 && /usr/sbin/upsdrvctl shutdown
```

**Figure 17**: openSUSE script for delayed UPS shutdown.


In all these cases, the file name “`nutshutdown`” seems to me to be a misnomer, since it is not NUT which is being shut down, but such naming sloppiness is common.

**Warning**: This script is executed late in the system shutdown process, and there is no trace in the system log of it’s action. If, like the editor, you believe that shutting off power to a system is a major event, and should be logged, then you are invited to replace the script provided by NUT with a systemd service unit as shown in appendix B which will log the delayed shutdown command.
2.6 The shutdown story for a simple server

We are now ready to tell the detailed story of how the server gets shut down when wall power fails, and how it restarts when wall power returns.

1. **Wall power on**  The system runs normally. In the attachment daemon the upsd status is `[OL]`. No NOTIFY event.

   *Days, weeks, months go by...*

2. **Wall power fails**  The server remains operational running on the UPS battery. upsd polls the UPS, and detects status change `[OL]`→`[OB]`.

3. In the management daemon, upsmon polls upsd, receives `[OB]` and issues NOTIFY event `[ONBATT]`. As instructed by line 58 an `[ONBATT]` message goes to syslog and to program `wall`. The server is still operational running on the UPS battery.

   *Minutes go by...*

4. **Battery discharges below battery.charge.low**  The server remains operational, but the UPS battery will not last much longer. upsd polls the UPS, and detects status change `[OB]`→`[OB LB]`.

5. upsmon polls upsd, receives `[OB LB]` and issues new NOTIFY event `[LOWBATT]`. As instructed by line 59 upsmon sends a `[LOWBATT]` message to syslog and to program `wall`.

6. upsmon decides to command a system shutdown and generates NOTIFY event `[SHUTDOWN]`. It also sends command FSD to upsd to tell any secondaries that they must shut down. There are no secondaries in this simple configuration.

7. upsmon uses command `NUMATTACH` to query the number of secondaries currently operational. In this simple configuration, the reply is 1, there are no secondaries and the primary may proceed to shut down.

8. upsmon waits `FINALDELAY` seconds as specified on line 69.

9. upsmon creates `POWERDOWN` flag specified on line 46.

10. upsmon calls the `SHUTDOWNCMD` specified on line 45.

11. We now enter the scenario described in figure 16. The operating system’s shutdown process takes over. During the system shutdown, the Bash script shown in figure 17 or equivalent systemd service unit or some other equivalent runs the command `upsdrvctl shutdown`. This tells the UPS that it is to shut down 20 seconds later.

12. The system powers down, hopefully before the 20 seconds have passed.

13. **UPS shuts down**  20 seconds have passed. With some UPS units, there is an audible “clunk”. The UPS outlets are no longer powered. The absence of AC power to the protected

---

NUMATTACH was known as NUMLOGINS up to NUT 2.7.4.
system for a sufficient time has the effect of resetting the BIOS options, and in particular the option “Restore power on AC return”. This BIOS option will be needed to restart the box. How long is a sufficient time for the BIOS to reset? This depends very much on the box. Some need more than 10 seconds. What if wall power returns before the “sufficient time” has elapsed? The UPS unit will wait until the time specified by the ondelay option in file `ups.conf`. This timer, like the offdelay timer, starts from the moment the UPS receives the `upsdrvctl shutdown` command. See line 78 in figure 18.

Minutes, hours, days go by...

14. **Wall power returns** Some time later, maybe much later, wall power returns. The UPS reconnects it’s outlets to send power to the protected system.

15. The system BIOS option “Restore power on AC return” has hopefully been selected and the system powers up. The bootstrap process of the operating system begins.

16. The operating system starts the NUT daemons `upsd` and `upsmon`. Daemon `upsd` starts the driver(s) and scans the UPS. The UPS status becomes `[OL LB]`. Daemon `upsmon` sends command `ATTACH`\(^8\) to `upsd` to advise `upsd` that the primary is operational, i.e. the number of attached systems is \(\geq 1\).

17. After some time, the battery charges above the `battery.charge.low` threshold and `upsd` declares the status change `[OL LB] \rightarrow [OL]`. We are now back in the same situation as state 1 above.

As we saw in figure 16 there is a danger that the system will take longer than 20 seconds to shut down. If that were to happen, the UPS shutdown would provoke a brutal system crash. To alleviate this problem, the next chapter proposes an improved configuration file `ups.conf`.

\(^8\)ATTACH was known as LOGIN up to NUT 2.7.4.
## 2.7 Configuration file `ups.conf` for a simple server, improved

Let's revisit this configuration file which declares your UPS units.

```plaintext
# ups.conf, improved
[UPS-1]
driver = usbhid-up
port = auto
desc = "Example Mfg 1600"
offdelay = 60
ondelay = 70
lowbatt = 33
```

Figure 18: Configuration file `ups.conf`, improved.

New line 77 increases from the default 20 secs to 60 secs the time that passes between the `upsdrvctl shutdown` command and the moment the UPS shuts itself down.

Line 78 increases the time that must pass between the `upsdrvctl shutdown` command and the moment when the UPS will react to the return of wall power and turn on the power to the system. Even if wall power returns earlier, the UPS will wait `ondelay = 70` seconds before powering itself on. The default is 30 seconds.

The `ondelay` must be greater than the `offdelay`. See `man ups.conf` for more news about this configuration file.

Additional line 79 sets the default value for `battery.charge.low`. Even if you use command `upsrw` to set a value for `battery.charge.low`, `usbhid-up` and some other driver will restore the default, so if you want a permanent change you must change the default. See also chapter 2.10.

## 2.8 The shutdown story with quick power return

What happens if power returns after the system shuts down but before the UPS delayed shutdown? We pick up the story from state 6.

6. `upsmon` decides to command a system shutdown and generates NOTIFY event `[SHUTDOWN]`. It also sends command `FSD` to `upsd` to tell any secondaries that they must shut down. There are no secondaries in this simple configuration.

7. `upsmon` uses command `NUMATTACH` to query the number of secondaries currently operational. In this simple configuration, the reply is 1, since there are no secondaries. The primary may proceed to shut down.

8. `upsmon` waits `FINALDELAY` seconds as specified on line 69.

9. `upsmon` creates `POWERDOWN` flag specified on line 46.

10. `upsmon` calls the `SHUTDOWNCMD` specified on line 45.

11. We now enter the scenario described in figure 16. The operating system’s shutdown process takes over. During the system shutdown, the Bash script shown in figure 17 or equivalent systemd service unit or some other equivalent runs the command `upsdrvctl shutdown`. This tells the UPS that it is to shut down `offdelay` seconds later.

9 List needed
12. The system powers down before offdelay seconds have passed.

13. **Wall power returns before the UPS shuts down** Less than offdelay seconds have passed. The UPS continues it’s shutdown process.

14. After offdelay seconds the UPS shuts down, disconnecting it’s outlets. The beeping stops. With some UPS units, there is an audible “clunk”.

   *An interval of ondelay-offdelay seconds later*

15. After ondelay seconds the UPS turns itself on, and repowers it’s outlets.

16. The system BIOS option “restore power on AC return” has hopefully been selected and the system powers up. The bootstrap process of the operating system begins.

   *The story continues at state 16 in chapter 2.6*

### 2.9 Utility program upscmd

Utility program upscmd is a command line program for sending commands directly to the UPS. To see what commands your UPS will accept, type upscmd -l ups-name where ups-name is the name of the UPS as declared in file ups.conf, line 32.

For example, to turn on the beeper, use command

```
upscmd -u nut-admin -p sekret UPS-1@localhost beeper.enable
```

where nut-admin is the user declared on line 40 and sekret is the l33t password declared on line 41 in file upsd.users.

Command upscmd can be dangerous. Make sure that file upsd.users can be read and written by root only. See man upscmd for more detail.

### 2.10 Utility program upsrw

Utility program upsrw is a command line program for changing the values of UPS variables. To see which variables may be changed, type upsrw ups-name where ups-name is the name of the UPS as declared in file ups.conf, line 32.

For example, at line 9 we saw that the battery.charge.low has been set to 50. We will change this to something less conservative with command

```
upsrw -s battery.charge.low=33 -u nut-admin -p sekret UPS-1@localhost
```

where nut-admin is the user declared on line 40 and sekret is the password declared on line 41 in file upsd.users. Now check that the value has been set with command

```
upsc UPS-1 battery.charge.low
```

which returns the value 33.

Once again, command upsrw can be dangerous. Make sure that file upsd.users can be read and written by root only. See man upsrw for more detail.
Some drivers, for example `usbhid-ups`, reset `battery.charge.low` to the default value when they start. To overcome this resistance, add the line `lowbatt = 33` to the UPS definition in file `ups.conf` as shown on line 79.

---

This chapter has described a basic configuration which is deficient in several ways:

- **NUT messages are only available to those users who are constantly in front of text consoles which display the output of the program `wall`.** Systems with users of graphical interfaces which do not display `wall` output will need stronger techniques.

- **Program `wall` has not been internationalised.** It cannot display letters with accents or any non-Latin character.

Chapter 4 will show how to overcome these difficulties.
3 Server with multiple power supplies

This chapter extends the ideas of chapter 2 to cover a larger server which has multiple, hopefully independent power supplies. The server is capable of running on two or more power supplies, but must be shut down if there are less than two operational. The flexibility of NUT makes this configuration easy: we will describe only the modifications to the configuration in chapter 2.

![Diagram of server with multiple power supplies]

Figure 19: Server with multiple power supplies.

Six configuration files specify the operation of NUT in the server with multiple power supplies.

1. The NUT startup configuration: nut.conf. Since this file is not strictly a part of NUT, and is common to all configurations, it is discussed separately in appendix A.

2. The upsd UPS declarations: ups.conf, see chapter 3.1

3. The upsd daemon access control; upsd.conf does not change, see chapter 2.2.

4. The upsd daemon user declarations: upsd.users do not change, see chapter 2.3.

5. The upsmon daemon configuration: upsmon.conf, see chapter 3.2.

6. The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix B.

3.1 Configuration file ups.conf for multiple power supplies

We add additional sections to ups.conf to declare the additional UPS units but we need some way of distinguishing them. Assuming the usbhid-ups driver, man usbhid-ups describes how this can be done.
# ups.conf, 4 power supplies

[UPS-1]
  driver = usbhid-ups
  port = auto
  desc = "Power supply 1"
  lowbatt = 33
  serial = 47014

[UPS-2]
  driver = usbhid-ups
  port = auto
  desc = "Power supply 2"
  lowbatt = 33
  serial = 47015

[UPS-3]
  driver = usbhid-ups
  port = auto
  desc = "Power supply 3"
  lowbatt = 33
  serial = 47024

[UPS-4]
  driver = usbhid-ups
  port = auto
  desc = "Power supply 4"
  lowbatt = 33
  serial = 47025

Figure 20: File *ups.conf* for multiple power supplies.

Driver *usbhid-ups* distinguishes multiple UPS units with some combination of the *vendor*, *product*, *serial* and *vendorid* options that it provides. For other drivers, which do not provide the ability to distinguish UPS units, or for UPS units which have no serial number, see the comment by Charles Lepple in NUT issue #597 at [https://github.com/networkupstools/nut/issues/597](https://github.com/networkupstools/nut/issues/597).

Let’s assume that the UPS units used in this configuration are sophisticated products and are capable of reporting their serial numbers. You can check this with command `upsc UPS-1@localhost ups.serial`. In lines 86, 92, 98 and 104 we use this information to distinguish UPS-1 with *serial* = 47014, UPS-2 with *serial* = 47015, etc.

See `man ups.conf` and `man usbhid-ups`.

### 3.2 Configuration file *upsmon.conf* for multiple power supplies

This configuration file declares how *upsmon* is to handle NOTIFY events from the UPS units. For good security, ensure that only users *nut* and root can read and write this file.

```
# upsmon.conf, multiple power supplies
MONITOR UPS-1@localhost 1 nut-admin sekret primary
MONITOR UPS-2@localhost 1 nut-admin sekret primary
MONITOR UPS-3@localhost 1 nut-admin sekret primary
MONITOR UPS-4@localhost 1 nut-admin sekret primary
MINSUPPLIES 2
```

Figure 21: Configuration file *upsmon.conf* for multiple power supplies, part 1 of 5.

On lines 106-109

10 This is for Debian 11. See table 104 in appendix C for other user names.
• The UPS names UPS-1, UPS-2, etc. must correspond to those declared in ups.conf lines 81, 87, 93 and 99.

• The “power value” 1 is the number of power supplies that each UPS feeds on this system.

• nut-admin is the “user” declared in upsd.users line 40

• sekret is the password declared in upsd.users line 41

• primary means this system will shutdown last, allowing any secondaries time to shutdown first. Secondary systems will be discussed in chapter 5. There are no secondaries in this configuration.

Line [110, MINSUPPLIES], declares that at least two power supplies must be operational, and that if fewer are available, NUT must shut down the server. Figure 19 shows that currently two of the four power supplies are operational. The [OB LB] of UPS-2, which would have caused a system shutdown in the case of the simple server in chapter 2 is not sufficient to provoke a system shutdown in this case. UPS-3 has been disconnected and will be removed in order to paint the wall behind it. (Have you ever worked for Big Business IT, or for Big Government IT?).

The remainder of upsmon.conf is the same as that for the simple server of chapter 2; figures [11-15]

### 3.3 Shutdown conditions for multiple power supplies

```
rprice@maria:~> for i in {1..100}
  > do upsc UPS-1 ups.status 2>&1
  > sleep 5s
  > done
  OL CHRG
  OL CHRG

  **Action: disconnect UPS-1 USB cable**

  Broadcast Message from upsd@maria
  UPS UPS-1@localhost: Communications lost
  Error: Data stale
  Error: Data stale

  **Action: reconnect UPS-1 USB cable**

  Broadcast Message from upsd@maria
  UPS UPS-1@localhost: Communications (re-)established
  OL CHRG
  OL CHRG
```

Figure 22: Experiment to show effect of lost UPS. Part 1,

The value of MINSUPPLIES is the key element in determining if a server with multiple power supplies should shut down. When all the UPS units can be contacted, and when their ups.status
values are known, then it is the count $A$ of those that are active, that is without $[LB]$, which is determinant.

If $A \geq \text{MINSUPPLIES}$ then OK else shutdown.

**UPS-3: What is the value of $A$?** The situation for those UPS units such as **UPS-3** is more delicate. If a UPS unit had been reporting the status $[OL]$, then if communication is lost, NUT assumes that the UPS is still operational. Command `upsc UPS-3@localhost ups.status` will return the error message “Error: Data stale”, `upsmon` will raise the NOTIFY event $[\text{COMMBAD}]$ and the sysadmin will receive the “Communications lost” message shown on line 54. However this does not count as an $[LB]$.

You can verify this yourself on a simple working configuration such as that of chapter 2 using the Bash command shown on lines 111-114 in figure 22. Disconnecting the USB cable on a **healthy** UPS does not cause a system shutdown.

```
125 rprice@maria:~> for i in {1..100}
126 > do upsc UPS-1 ups.status 2>&1
127 > sleep 5s
128 > done
129 OL CHRG
130 OL CHRG
131 OB
132 OB
133 Broadcast Message from ups@primary
134 UPS UPS-1@primary: Communications lost
135 Error: Data stale
136 Error: Data stale
```

Figure 23: Experiment to show effect of lost UPS. Part 2,

However, as shown in figure 23 disconnecting the USB lead on a **sick** UPS causes a rapid system shutdown. If a UPS unit had been reporting the status $[OB]$, then if communication is lost, NUT assumes that the UPS is about to reach status $[OB LB]$ and calls for a immediate system shutdown.

So the value of $A$ depends not only on the current situation, but also on how the system got into that state.

The moral of our story is that NUT will play safe, but you must be very careful who has access to your server room. We will see in later chapters that there are ways of reinforcing the feedback to the sysadmin.
This chapter has described a complex UPS configuration in isolation, but in practice such a configuration would be just a part of a complete server room, and the use of NUT would have to be integrated with the rest of the server room power management. The layered design of NUT makes this integration possible.

A recent book\footnote{The Backup Book: Disaster Recovery from Desktop to Data Center” by Dorian J. Cougias, E. L. Heiberger, Karsten Koop, Schaser-Vartan Books, 2003, ISBN 0-9729039-0-9, 755 pages.} for managers on disaster recovery discusses UPS units. On page 559 it says “We chose to have just one UPS do the paging ... We do it on low battery for one of the UPSes that has a 15-minute run-time.” Clearly they wanted a timed action, but the only way they could get it was by running down a UPS until it reached \([lb]\). NUT is capable of doing a lot better, as we will show in later chapters.
4 Workstation with local users

This chapter extends the ideas of chapter [2] to provide a fully worked example of a configuration which includes a simple user provided script. This will in turn form the basis for future chapters.

There are two approaches possible for supporting user scripts:

1. Directly from **upsmon** using **NOTIFYCMD**.
2. Indirectly via **upssched** and **CMDSCRIPT**.

We choose the latter since this introduces **upssched**, which will be needed later.

Eight configuration files specify the operation of NUT in the workstation.

1. The NUT startup configuration: **nut.conf**. Since this file is not strictly a part of NUT, and is common to all configurations, it is discussed separately in appendix [A].
2. The **upsd** UPS declarations: The improved file **ups.conf** as given in chapter [2.7] does not change.
3. The **upsd** daemon access control: File **upsd.conf** as given in chapter [2.2] does not change.
4. The **upsd** user declarations: File **upsd.users** as given in chapter [2.3] does not change.
5. The **upsmon** daemon configuration: **upsmon.conf**. See chapter [4.1].
6. The **upssched** configuration: **upssched.conf**. See chapter [4.2]
7. The **upssched-cmd** script: see chapter [4.3].
8. The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix [B].
4.1 Configuration file `upsmon.conf` for a workstation

```
# upsmon.conf
MONITOR UPS-1@localhost 1 nut-admin sekret primary
MINSUPPLIES 1
```

Figure 25: Configuration file `upsmon.conf` for a workstation, part 1 of 5.

This configuration file declares how `upsmon` is to handle NOTIFY events. For good security, ensure that only users `nut`\(^{12}\) and root can read and write this file.

Line 138 is the same as line 44 in the previous chapter.

On line 139 `MINSUPPLIES` sets the number of power supplies that must be receiving power to keep this system running. Computers commonly have just one power supply, so the default value of 1 is acceptable. See `man upsmon.conf` for more details.

```
SHUTDOWNCMD "/sbin/shutdown -h +0"
NOTIFYCMD /usr/sbin/upssched
POLLFREQ 5
POLLFREQALERT 5
HOSTSYNC 15
DEADTIME 15
POWERDOWNFLAG /etc/killpower
```

Figure 26: Configuration file `upsmon.conf` for a workstation, part 2 of 5.

Line 140 identical to line 45 declares the command to be used to shut down the server.

Line 141 says which program is to be invoked when `upsmon` detects a NOTIFY event flagged as EXEC. The directory/file `/usr/sbin/upssched` is for Debian 11. Sysadmins for other distributions should check the directory used.

Line 142 `POLLFREQ`, declares that the `upsmon` daemon will poll `upsd` every 5 seconds.

Line 143 `POLLFREQALERT`, declares that the `upsmon` daemon will poll `upsd` every 5 seconds while the UPS is on battery.

Line 144 `HOSTSYNC` will be used in primary-secondary\(^{13}\) cooperation, to be discussed in chapter 5.5. The default value is 15 seconds.

Line 145 specifies how long `upsmon` will allow a UPS to go missing before declaring it “dead”. The default is 15 seconds.

Daemon `upsmon` requires a UPS to provide status information every few seconds as defined by `POLLFREQ` and `POLLFREQALERT`. If the status fetch fails, the UPS is marked stale. If it stays stale for more than `DEADTIME` seconds, the UPS is marked dead.

A dead UPS that was last known to be on battery `[OB]` is assumed to have changed to a low battery condition `[OB]→[OB LB]`. This may force a shutdown. Disruptive, but the alternative is

\(^{12}\) This is for Debian 11. See table 104 in appendix C for other user names.

\(^{13}\) A secondary is a second, third, ... PC or workstation sharing the same UPS,
barreling ahead into oblivion and crashing when you run out of power. See chapter 3.3 for more discussion.

```
147 NOTIFYMSG ONLINE "UPS %s: On line power."
148 NOTIFYMSG ONBATT "UPS %s: On battery."
149 NOTIFYMSG LOWBATT "UPS %s: Battery is low."
150 NOTIFYMSG REPLBATT "UPS %s: Battery needs to be replaced."
151 NOTIFYMSG FSD "UPS %s: Forced shutdown in progress."
152 NOTIFYMSG SHUTDOWN "Auto logout and shutdown proceeding."
153 NOTIFYMSG COMMOK "UPS %s: Communications (re-)established."
154 NOTIFYMSG COMMBAD "UPS %s: Communications lost."
155 NOTIFYMSG NOCOMM "UPS %s: Not available."
156 NOTIFYMSG NOPARENT "upsmon parent dead, shutdown impossible."
```

Figure 27: Configuration file upsmon.conf for a workstation, part 3 of 5.

The message texts on lines 147-156 in figure 27 do not change.

```
157 NOTIFYFLAG ONLINE SYSLOG+WALL+EXEC
158 NOTIFYFLAG ONBATT SYSLOG+WALL+EXEC
159 NOTIFYFLAG LOWBATT SYSLOG+WALL+EXEC
160 NOTIFYFLAG REPLBATT SYSLOG+WALL
161 NOTIFYFLAG FSD SYSLOG+WALL
162 NOTIFYFLAG SHUTDOWN SYSLOG+WALL
163 NOTIFYFLAG COMMOK SYSLOG+WALL
164 NOTIFYFLAG COMMBAD SYSLOG+WALL
165 NOTIFYFLAG NOCOMM SYSLOG+WALL
166 NOTIFYFLAG NOPARENT SYSLOG+WALL
```

Figure 28: Configuration file upsmon.conf for a workstation, part 4 of 5.

Lines 157-159 now carry the EXEC flag: this flag means that when the NOTIFY event occurs, upsmon calls the program identified by the NOTIFYCMD on line 141.

Lines 160-166 do not change.

```
167 RBWARNTIME 43200
168 NOCOMMWARNTIME 300
169 FINALDELAY 5
```

Figure 29: Configuration file upsmon.conf for a workstation, part 5 of 5.

Lines 167-169 are the same as lines 67-69
4.2 Configuration file `upssched.conf` for a workstation

The NOTIFY events detected by `upsmon` and flagged as EXEC in `upsmon.conf` become events for `upssched` when NOTIFYCMD points to `upssched`. The program `upssched` provides a richer set of actions than `upsmon`.

The configuration file `upssched.conf` described here shows only a simple subset of what can be done. We will see more later.

```
# upssched.conf
CMDSCRIPT /usr/bin/upssched-cmd
# PIPEFN LOCKFN suitable for Debian 11
PIPEFN /run/nut/upssched.pipe
LOCKFN /run/nut/upssched.lock
```

Figure 30: Configuration file `upssched.conf` for a Debian 11 workstation, Part 1.

On line 171 `CMDSCRIPT` points to a user script to be called for designated NOTIFY events. This script will receive as argument a user chosen value. The specification `/usr/bin/upssched-cmd` is for Debian 11. Sysadmins of other distributions should check the directory used.

Line 173 defines `PIPEFN` which is the file name of a socket used for communication between `upsmon` and `upssched`. It is important that the directory be accessible to NUT software and nothing else. I recommend that you use the same directory as is used for communication between `upsd` and the drivers. Search for the directory which contains the file `upsd.pid`. You should see at least one socket. See for example the footnote to section 1.3.1.

The value shown on line 173 is for the Debian 11 distribution which places `upsd.pid` in directory `/run/nut/`. As always, sysadmins for other distributions should check the directory used. You should see an additional entry in the directory:

```
srw-rw---- 1 nut nut 0 Aug 7 15:57 upssched.pipe=
```

On line 174 the `LOCKFN` declaration is needed by daemon `upsmon` to avoid race conditions. The directory should be the same as `PIPEFN`.

4.2.1 The AT declaration.

```
AT ONLINE UPS-1@localhost EXECUTE online
AT ONBATT UPS-1@localhost EXECUTE onbatt
AT LOWBATT UPS-1@localhost EXECUTE lowbatt
```

Figure 31: Configuration file `upssched.conf` for a Debian 11 workstation, Part 2.

Line 176 introduces the very useful AT declaration provided by `upssched.conf`. This has the form
AT notifytype UPS-name command

where

- **notifytype** is a symbol representing a NOTIFY event.
- **UPS-name** can be the special value “*” to apply this handler to every possible value of UPS-name. I strongly recommend that you do not use this wildcard, since in later chapters we need distinct actions for distinct UPS's.
- The **command** in this case is **EXECUTE**. In later chapters we will see other very useful commands.

Line 176 says what is to be done by **upssched** for event [**ONLINE**]. The field “**UPS-1@localhost**” says that it applies to the UPS we are using, and the **EXECUTE** says that the user script specified by **CMDSCRIPT** is to be called with argument “**online**”.

Lines 177 and 178 make similar declarations for NOTIFY events [**ONBATT**] and [**LOWBATT**].

### 4.3 Configuration script upssched-cmd for a workstation

When **upssched** was added to the NUT project, the user defined script was called “**upssched-cmd**”. This is not the most elegant of names but if you use it, people in the NUT community will know immediately what you mean. Ubuntu sysadmins sometimes use **upssched-script** which is better.

```bash
#!/bin/bash -u
# upssched-cmd
logger -i -t upssched-cmd Calling upssched-cmd $1

UPS="UPS-1"
STATUS=$( upsc $UPS ups.status )
CHARGE=$( upsc $UPS battery.charge )
CHMSG="[$STATUS]:$CHARGE%"

case $1 in
  online) MSG="$UPS, $CHMSG - power supply has been restored." ;;
  onbatt) MSG="$UPS, $CHMSG - power failure - save your work!" ;;
  lowbatt) MSG="$UPS, $CHMSG - shutdown now!" ;;
  *) logger -i -t upssched-cmd "Bad arg: "$1", $CHMSG"
       exit 1 ;;
esac

logger -i -t upssched-cmd $MSG
notify-send-all "$MSG"
```

Figure 32: Configuration script **upssched-cmd** for a workstation.
Figure 32 shows a simple example of the script. Since NUT runs on a wide range of operating
systems and distributions, with different default scripting languages, it is wise to declare as on line
179 which scripting language is used.

Logging all calls to this script helps sysadmins to discover what went wrong after the catastrophic
failures which in theory should never occur, but which in practice do. Line 181 logs all calls to this
script.

Lines 183-185 prepare a Bash variable CHMSG which gives the current UPS status and battery
charge. This is to be included in messages, so we get a clearer idea of what is happening.

On line 186 the value of the Bash variable $1 is one of the EXECUTE tags defined on lines 176-178.
Lines 187-189 define, for each possible NOTIFY event that upsmon passes on to upssched, a
message to be logged and put in front of users. Accented letters and non latin characters are
allowed.

Line 193 logs the upssched action, and line 194 calls program notify-send-all to put the message
in front of the users. For details of notify-send-all, see appendix D, “Using notify-send”. See also
notify-send --help. There is no man page.

It is important that script upssched-cmd be accessible to NUT software and nothing else. For
example the following restrictive ownership and permissions seen on a Debian 11 site:

```
root@titan ~ ls -alF /usr/bin/upssched-cmd
-rw-r--r-- 1 nut daemon 8444 Aug  6 18:07 /usr/bin/upssched-cmd*
```
4.4 The shutdown story for a workstation

We are now ready to tell the detailed story of how the workstation gets shut down when wall power fails, and how it restarts when wall power returns.

1. **Wall power on** The system runs normally. `upsd` status is `[OL]`. No NOTIFY event.

   Days, weeks, months go by...

2. **Wall power fails** The server remains operational running on the UPS battery. `upsd` polls the UPS, and detects status change `[OL] → [OB]`.

3. `upsmon` polls `upsd`, receives status `[OB]` and issues NOTIFY event `[ONBATT]`. As instructed by line 158 an `[ONBATT]` message goes to syslog, to program `wall` and to `upssched`. The server is still operational, running on the UPS battery.

4. `upssched` ignores the message it receives and follows the instruction on line 177 to call the user script `upssched-cmd` with parameter `onbatt`.

5. User script `upssched-cmd` sees that `$1 = onbatt` and on line 188 sets Bash variable `$MSG` to `UPS-1, [OB DISCHRG]:99% - power failure - save your work!`

6. On line 193 the message is logged, and on line 194 program `notify-send-all` notifies the users.

   Minutes go by...

7. **Battery discharges below battery.charge.low** The server remains operational, but the UPS battery will not last much longer. `upsd` polls the UPS, and detects status change `[OB] → [OB LB]`.

8. `upsmon` polls `upsd`, receives status `[OB LB]` and issues new NOTIFY event `[LOWBATT]`. As instructed by line 159 `upsmon` sends a `[LOWBATT]` message to syslog, to program `wall` and to `upssched`.

   The following `upssched` actions may not occur if the system shutdown is rapid.

9. `upssched` ignores the message it receives and follows the instruction on line 178 to call the user script `upssched-cmd` with parameter `lowbatt`.

10. User script `upssched-cmd` sees that `$1 = lowbatt` and on line 189 sets Bash variable `$MSG` to `UPS-1, [OB DISCHRG LB]:12% - shutdown now!`

11. On line 193 the message is logged, and on line 194 program `notify-send` notifies the users.

   The shutdown story now continues as for the simple server in state 6.
5 Workstations share a UPS

This chapter discusses a variant of the workstation configuration of chapter 4: multiple workstations on the same UPS unit.

Figure 33: “Secondary” workstations take power from same UPS as “primary”.

In this configuration two or more workstations are powered by the same UPS unit. Only one, the “primary”, has a control lead to the UPS. The other(s) do not have control leads to the UPS and are known as “secondaries”.

Figure 33 shows the arrangement. The NUT configuration for the primary workstation is identical to that of chapter 4.

Five configuration files specify the operation of NUT in the secondary workstation.

1. The NUT startup configuration: nut.conf. Since there is no control lead to the UPS, there is no need for upsd or a driver in the secondary. In nut.conf declare MODE=netclient since only upsmon needs to be started. You will probably need to review your distribution’s start-up scripts to achieve this. If upsd is started but without any UPS specified, it usually does no harm. See also appendix A.

2. The upsmon daemon configuration: upsmon.conf. See chapter 5.1.

3. The upssched configuration: upssched.conf. See chapter 5.2.

4. The upssched-cmd script: see chapter 5.3.

5. The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix B.
## 5.1 Configuration file *upsmon.conf* for a secondary

This configuration file declares how *upsmon* in the secondary is to handle NOTIFY events coming from the primary. For good security, ensure that only users *nut*¹⁴ and root can read and write this file.

On line 198

- The UPS name *UPS-1* must correspond to that declared in the primary *ups.conf*, line 32. The fully qualified name *UPS@host* includes the network name of the primary workstation, in this case *primary*.
- The “power value” 1 is the number of power supplies that this UPS feeds on this system.
- *nut-admin* is the “user” declared in primary *upsd.users* line 40.
- *sekret* is the password declared in primary *upsd.users* line 41.
- *secondary* means this system will shutdown first, before the primary.

On line 199, **MINSUPPLIES** sets the number of power supplies that must be receiving power to keep this system running. Normal computers have just one power supply, so the default value of 1 is acceptable. See chapter 3 and *man upsmon.conf* in the NUT documentation for more details.

```
# upsmon.conf -- secondary --
MONITOR UPS-1@primary 1 nut-admin sekret secondary
MINSUPPLIES 1
```

Figure 34: Configuration file *upsmon.conf* for a secondary, part 1 of 5.

```
SHUTDOWNCMD "/sbin/shutdown -h +0"
NOTIFYCMD /usr/sbin/upssched
POLLFREQ 5
POLLFREQALERT 5
HOSTSYNC 15
DEADTIME 15
POWERDOWNFLAG /etc/killpower
```

Figure 35: Configuration file *upsmon.conf* for a secondary, part 2 of 5.

Line 200 identical to line 45, declares the command to be used to shut down the secondary.

Line 201 says which program is to be invoked when *upsmon* detects a NOTIFY event flagged as EXEC. Debian administrators would probably specify /sbin/upssched.

Line 202, **POLLFREQ**, declares that the *upsmon* daemon will poll *upsd* in the primary every 5 seconds.

¹⁴I've seen user *upsd* rather than *nut* in distributions. See table 104 in appendix C.
Line 203, `POLLFREQALERT`, declares that the `upsmon` daemon will poll `upsd` in the primary every 5 seconds while the UPS is on battery.

Line 204, `HOSTSYNC`\(^\text{15}\) will be used as a safeguard for the primary-secondary shutdown sequence, preventing the overall shutdown being blocked by an unresponsive secondary, as discussed in chapter 5.4. The default value is 15 seconds.

Line 205 specifies how long the secondary `upsmon` will allow a UPS to go missing before declaring it “dead”. The default is 15 seconds.

Daemon `upsmon` requires a UPS to provide status information every few seconds as defined by `POLLFREQ` and `POLLFREQALERT`. If the status fetch fails, the UPS is marked stale. If it stays stale for more than `DEADTIME` seconds, the UPS is marked dead.

A dead UPS that was last known to be on battery `[OB]` is assumed to have changed to a low battery condition `[OB]→[OB LB]`. This may force a shutdown. Disruptive, but the alternative is barreling ahead into oblivion and crashing when you run out of power. See chapter 3.3 for more discussion.

```
207 NOTIFYMSG ONLINE "UPS %s: On line power."
208 NOTIFYMSG ONBATT "UPS %s: On battery."
209 NOTIFYMSG LOWBATT "UPS %s: Battery is low."
210 NOTIFYMSG REPLBATT "UPS %s: Battery needs to be replaced."
211 NOTIFYMSG FSD "UPS %s: Forced shutdown in progress."
212 NOTIFYMSG SHUTDOWN "Auto logout and shutdown proceeding."
213 NOTIFYMSG COMMOK "UPS %s: Communications (re-)established."
214 NOTIFYMSG COMMBAD "UPS %s: Communications lost."
215 NOTIFYMSG NOCOMM "UPS %s: Not available."
216 NOTIFYMSG NOPARENT "upsmon parent dead, shutdown impossible."
```

Figure 36: Configuration file `upsmon.conf` for a secondary, part 3 of 5.

The message texts on lines 207-216 in figure 36 do not change from those in the primary.

```
217 NOTIFYFLAG ONLINE SYSLOG+WALL+EXEC
218 NOTIFYFLAG ONBATT SYSLOG+WALL+EXEC
219 NOTIFYFLAG LOWBATT SYSLOG+WALL+EXEC
220 NOTIFYFLAG REPLBATT SYSLOG+WALL
221 NOTIFYFLAG FSD SYSLOG+WALL
222 NOTIFYFLAG SHUTDOWN SYSLOG+WALL
223 NOTIFYFLAG COMMOK SYSLOG+WALL
224 NOTIFYFLAG COMMBAD SYSLOG+WALL
225 NOTIFYFLAG NOCOMM SYSLOG+WALL
226 NOTIFYFLAG NOPARENT SYSLOG+WALL
```

Figure 37: Configuration file `upsmon.conf` for a secondary, part 4 of 5.

\(^{15}\) The name “HOSTSYNC” is misleading. It would be clearer if the name were say “MAXWAITSCNDRY”. 
Lines 217-219, which do not change from those in the primary, carry the EXEC flag: when the NOTIFY event occurs, secondary *upsmon* calls the program identified by the NOTIFYCMD on line 201.

Lines 220-226 do not change from those in the primary.

```
227 RBWARNTIME 43200
228 NOCOMMWARNTIME 300
229 FINALDELAY 5
```

Figure 38: Configuration file *upsmon.conf* for a secondary, part 5 of 5.

Lines 227-229 are the same as lines 67-69 in the primary.

### 5.2 Configuration file *upssched.conf* for a secondary

The NOTIFY events detected by secondary *upsmon* and flagged as EXEC in *upsmon.conf* become events for *upssched* when NOTIFYCMD points to *upssched*. The program *upssched* provides a richer set of actions than *upsmon*.

As with the primary in chapter 4, the configuration file *upssched.conf* described here shows only a simple subset of what can be done. We will see more later.

```
230 # upssched.conf -- secondary --
231 CMDSCRIPT /usr/sbin/upssched-cmd
232 PIPEFN /run/nut/upssched.pipe
233 LOCKFN /run/nut/upssched.lock
234
235 AT ONLINE UPS-1@primary EXECUTE online
236 AT ONBATT UPS-1@primary EXECUTE onbatt
237 AT LOWBATT UPS-1@primary EXECUTE lowbatt
```

Figure 39: Configuration file *upssched.conf* for a secondary.

On line 231, CMDSCRIPT points to a user script to be called for designated NOTIFY events. This script will receive as argument a user chosen value.

Line 232 defines PIPEFN which is the file name of a socket used for communication between *upsmon* and *upssched*. The value shown is for the Debian 11 distribution. For a detailed discussion of PIPEFN, see chapter 4.2, line 173.

Daemon *upsmon* requires the LOCKFN declaration on line 233 to avoid race conditions. The directory should be the same as PIPEFN.

Line 235 says what *upssched* should do for NOTIFY event [ONLINE]. The “UPS-1@primary” says that it applies to the UPS controlled by the primary, and the EXECUTE says that the user script specified by CMDSCRIPT is to be called with argument “online”.

Lines 236 and 237 make similar declarations for NOTIFY events [ONBATT] and [LOWBATT].
5.3 Configuration script **upssched-cmd** for a secondary

When *upssched* was added to the NUT project, the user defined script was called “*upssched-cmd*”. This is not the most elegant of names but if you use it, people in the NUT community will know immediately what you mean.

It is important that script **upssched-cmd** be accessible to NUT software and nothing else.

```bash
#!/bin/bash -u
# upssched-cmd  --secondary --
logger -i -t upssched-cmd Calling upssched-cmd $1

case $1 in
  online) MSG="UPS-1 - power supply had been restored." ;;
  onbatt) MSG="UPS-1 - power failure - save your work!" ;;
  lowbatt) MSG="UPS-1 - shutdown now!" ;;
  *) logger -i -t upssched-cmd "Bad arg: "$1"
    exit 1 ;;
esac
logger -i -t upssched-cmd $MSG
notify-send-all "$MSG"
```

Figure 40: Configuration script **upssched-cmd** for a secondary.

Since NUT runs on a wide range of operating systems and distributions, with different default scripting languages, it is wise to declare as on line 238 which scripting language is used.

Logging all calls to this script helps sysadmins to discover what went wrong after the catastrophic failures which in theory should never occur, but which in practice sometimes do. Line 240 logs all calls to this script.

On line 241 the value of the Bash variable $1 is one of the **EXECUTE** tags defined on lines 235-237.

Lines 242-244 define, for each possible NOTIFY event that *upsmon* passes on to *upssched*, a message to be logged and put in front of users of the secondary. Accented letters and non latin characters are allowed.

Line 248 logs the *upssched* action, and line 249 calls program *notify-send-all* to put the message in front of the secondary users. For details of *notify-send-all*, see appendix D “Using **notify-send**”. See also *notify-send* --help. There is no man page.
5.4 NUMATTACH: Counting the protected systems

The daemon upsdl maintains a count of the number of systems protected by a UPS unit. When a primary or secondary is brought up, it sends command ATTACH to upsdl which increases the count by 1. When a system is shut down, it sends command DETACH to upsdl and the count decreases by 1. In the configuration shown in figure 33 on page 32, during normal operation the count is 4. The primary upsmon instance polls the number of protected systems using command NUMATTACH. During a complete shutdown, the primary waits until the NUMATTACH value drops to 1 before shutting down itself.

However there is a safeguard against excessive waiting for a non-responsive secondary provided by the HOSTSYNC value declared on line 204.

5.5 Magic: How does the primary shut down the secondaries?

The primary commands the system shutdowns which may be due to an [LB], a timeout (chapter 7), or a sysadmin command. When there are secondaries to be shut down as well, then the primary expects them to shut down first. But how do the secondaries know that they are to shut down?

When the primary makes the shutdown decision, it places a status symbol [FSD] in variable ups.status in the abstract image of the UPS maintained by it’s upsdl. The secondary upsmon daemons poll upsdl every POLLFREQ seconds as declared on line 142, and when they see the [FSD] symbol, knowing that they are a secondary, they shut down immediately, sending command DETACH to upsdl. The primary waits for the secondaries to react and shutdown by polling the NUMATTACH value. The maximum waiting period is specified by HOSTSYNC on line 144. When NUMATTACH = 1, or after the HOSTSYNC time has elapsed, the primary will shut down, even if there is a secondary which has not yet completed it’s shutdown. If you meet this problem, you may have to increase the value of HOSTSYNC.

This HOSTSYNC value is also used to keep secondary systems from getting stuck if the primary fails to respond in time. After a UPS becomes critical, e.g. status [OB LB], the secondary will wait up to HOSTSYNC seconds for the primary to set the [FSD] flag. If that timer expires, the secondary will assume that the primary is broken and will shut down anyway. See also man upsmon.conf

---

16 The name “HOSTSYNC” is misleading. It would be clearer if the name were say “MAXWAITSCNDRY”.
6 Workstation with heartbeat

The NUT software runs in the background for weeks, months without difficulty and with no mes-
sages going the system administrator. “All is well!”, but is it? NUT is a collection of pieces and
interconnecting protocols. What if one of these pieces has stopped or the protocol blocked? We
need something that will check regularly that all is indeed well. The proposed heartbeat does this
job.

This chapter supposes that you already have a working configuration for a workstation.

How does it work? NUT program upssched runs permanently as a daemon managing an
11 minute timer. If this timer expires, NUT is broken, and upssched calls user script upssched-cmd
which issues wall messages, e-mails, notifications, etc. Meanwhile a dummy (software) UPS is
programmed to generate a status change every 10 minutes. This works it’s way through the NUT
daemons and protocols to reach user script upssched-cmd which then restarts the 11 minute timer.
As long as the 10 minute status changes are fully and correctly handled by NUT, the warning
message does not go out, but if something breaks, the 11 minute timer elapses.

Nine configuration files specify the operation of NUT in the workstation.

1. The NUT startup configuration: nut.conf. See appendix [A]
2. The upsd UPS declarations: ups.conf will be extended to include the heartbeat. See chapter
   6.1.
3. New configuration file heartbeat.conf defines the dummy UPS which provides the heartbeat.
   See chapter 6.2
4. The upsd daemon access control: File upsd.conf as given in chapter 2.2 stays the same.
5. The upsd user declarations: File upsd.users as given in chapter 2.3 does not change.
6. The upsmon daemon configuration: upsmon.conf. See chapter 6.3.
8. The upssched-cmd script: see chapter 6.5.
9. The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix B.

6.1 Configuration file ups.conf for workstation with heartbeat

We extend this configuration file with an additional section to declare a new UPS unit.

```plaintext
# ups.conf, heartbeat
[UPS-1]
driver = usbhid-ups
port = auto
desc = "Example Mfg Sparkly 1600"
offdelay = 60
ondelay = 70
lowbatt = 33

[heartbeat]
driver = dummy-ups
port = heartbeat.conf
mode = dummy-loop
desc = "Watch over NUT"
```

Figure 42: Configuration file ups.conf for workstation with heartbeat.

Lines 251–257 are unchanged.

New line 258 declares the new dummy UPS heartbeat. This will be a software creation which looks to NUT like a UPS, but which can be programmed with a script, and given arbitrary states. Line 259 says that this UPS is of type dummy-ups, i.e. a software UPS, for which the scripted behaviour will be in a file specified by the port declaration.

Line 260 says that the scripted behaviour is in file heartbeat.conf in the same directory as ups.conf. Up to 2.7.4 it was traditional in NUT development that such files had file type .dev. NUT 2.8.0 has introduced .seq, but we are in a production context, not development so we choose a more conventional name.

Starting with 2.8.0, .dev no longer implies the looping needed by a heartbeat, this is now called for by .seq. The implicit looping behaviour of other file names is no longer defined and must be configured explicitly with a mode declaration as shown on line 261.

See `man dummy-ups` for lots of details.
6.2 Configuration file `heartbeat.conf` for workstation

Heartbeat definitions are not provided by NUT, you have to create them yourself. Create the new file `heartbeat.conf` in the same directory as `ups.conf`. For security, only users `nut`\textsuperscript{17} and `root` should have write access to this file.

The dummy UPS will cycle continuously through this script.

Lines 264 and 266 flip the `ups.status` value between `[OL]` and `[OB].`

Lines 265 and 267 place a 5 minute time interval between each status change. Remember that $2 \times 300 \text{sec} = 10 \text{min}$, the heartbeat period.

6.3 Configuration file `upsmon.conf` for workstation with heartbeat

The configuration file `upsmon.conf` is the same as for the workstation in chapter 4 except for an additional `MONITOR` declaration and a simpler `NOTIFYFLAG` to avoid flooding the logs.

The change is the addition of line 270 which declares that `upsmon` is to monitor the heartbeat.

Note that the power value is “0” because the heartbeat does not supply power to the workstation.

To avoid flooding your logs, remove the flags `SYSLOG` and `WALL` for the `[ONLINE]` and `[ONBATT]` NOTIFY events:

All the other declarations remain unchanged. This inability of `upsmon` to provide different behaviours for different UPS’s is a weakness, and is why we prefer to make use of `upssched` which supports precise selection of the UPS in it’s AT specification.

\textsuperscript{17}Some distributions have been known to use upsd. See table 104 in appendix C for other user names.
6.4 Configuration file upssched.conf for workstation with heartbeat

We use upssched as a daemon to maintain an 11 minute timer which we call heartbeat-failure-timer. The timer is kept in memory, and manipulated with the commands START-TIMER and CANCEL-TIMER which are included in the AT facility which NUT provides as a part of upssched.conf. See man upssched.conf If this timer completes, upssched calls the user script upssched-cmd with the parameter heartbeat-failure-timer, and upssched-cmd will complain that NUT is broken.

The configuration file upssched.conf is the same as for the workstation in chapter 4 except for two additional declarations.

<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>274</td>
<td># Restart timer which completes only if the dummy-ups heartbeat has stopped. See timer values in heartbeat.conf</td>
</tr>
<tr>
<td>276</td>
<td>AT ONBATT heartbeat@localhost CANCEL-TIMER heartbeat-failure-timer</td>
</tr>
<tr>
<td>277</td>
<td>AT ONBATT heartbeat@localhost START-TIMER heartbeat-failure-timer 660</td>
</tr>
</tbody>
</table>

Figure 45: Configuration file upssched.conf for a workstation with heartbeat.

Remember that the very useful AT declaration provided by upssched.conf has the form

\[
\text{AT notifytype UPS-name command}
\]

On line 276 when upssched receives an [ONBATT] it executes the command which is CANCEL-TIMER heartbeat-failure-timer. This kills the timer. upssched does not call the user script.

Immediately afterwards, on line 277, and for the same [ONBATT] event, upssched executes the command START-TIMER heartbeat-failure-timer 660 which restarts the heartbeat-failure-timer which will run for 660 sec, i.e. 11 minutes. If the timer completes, upssched will call the user script upssched-cmd with parameter heartbeat-failure-timer.

Make sure that there are no entries such as

<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>278</td>
<td>AT ONLINE * ...</td>
</tr>
<tr>
<td>279</td>
<td>AT ONBATT * ...</td>
</tr>
</tbody>
</table>

which would be activated by an [ONLINE] or [ONBATT] from the heartbeat UPS. Replace the "*" with the full address of the UPS unit, e.g. UPS-1@localhost.

6.5 Script upssched-cmd for workstation with heartbeat

In upssched-cmd, we add additional code to test for completion of the heartbeat-failure-timer, and when it completes send a warning to the sysadmin by e-mail, SMS, pigeon, ...

Here is an example of what can be done. Note the e-mail address declarations in the head of the script, and the additional case after “case $1 in” beginning on line 297

On lines 285 and 286 change the e-mail addresses to something that works for you.

Lines 297-304 introduce the heartbeat-failure-timer case into the case statement. Line 298 specifies a message to be logged with the current UPS status as defined on lines 288-291.

Page 41 of 131
#!/bin/bash -u
# upssched-cmd for workstation with heartbeat
logger -i -t upssched-cmd Calling upssched-cmd $1

# Send emails to/from these addresses
EMAIL_TO="sysadmin@example.com"
EMAIL_FROM="upssched-cmd@$({HOSTNAME:-nut}.example.com"

UPS="UPS-1"
STATUS=$( upsc $UPS ups.status )
CHARGE=$( upsc $UPS battery.charge )
CHMSG="[$STATUS]:$CHARGE%"

case $1 in
  (online) MSG="$UPS, $CHMSG - power supply had been restored." ;;
  (onbatt) MSG="$UPS, $CHMSG - power failure - save your work!" ;;
  (lowbatt) MSG="$UPS, $CHMSG - shutdown now!" ;;
  (heartbeat-failure-timer)
    MSG="NUT heart beat fails. $CHMSG"
    # Email to sysadmin
    MSG1="Hello, upssched-cmd reports NUT heartbeat has failed."
    MSG2="Current status: $CHMSG \n\n$0 $1"
    MSG3="\n\n( ps -elf | grep -E 'ups[dms]|nut' )"
    echo -e "$MSG1 $MSG2 $MSG3" | /bin/mail -r "$EMAIL_FROM" -s "NUT heart beat fails. Currently $CHMSG" "$EMAIL_TO"
  (*) logger -i -t upssched-cmd "Bad arg: \"$1\", $CHMSG"
    exit 1 ;;
esac
logger -i -t upssched-cmd $MSG
notify-send-all "$MSG"

Figure 46: Configuration script upssched-cmd including heartbeat.

Lines [300-302] compose a message to the sysadmin which is sent on line 303. The message includes the current state of those NUT kernel processes which are operational.

A true sysadmin should not be satisfied with just the heartbeat. “What if the heartbeat dies silently?” We need a further independent check that the normally silent heartbeat is doing it’s job.
6.6 For paranoid sysadmins

We want to check that the heartbeat is in progress. To do so we make use of the permanent presence of a upssched process. Consider the following Bash script:

```bash
#!/bin/bash
NUT=nut # openSUSE: "upsd", Debian: "nut"
MSGERR="${HOSTNAME:-mybox}: NUT heartbeat fails"
MSGOK="${HOSTNAME:-mybox}: NUT heartbeat OK"
# Are the heartbeat timers keeping upssched busy?
ps -elf | grep "upssched UPS heartbeat" | grep $NUT > /dev/null
if [[ $? -ne 0 ]]
then
  wall $MSGERR # Tell sysadmin the bad news
  echo -e "$MSGERR" | /bin/mail
    -r heartbeat-watcher@example.com
    -s "$MSGERR" sysadmin@example.com
  notify-send-all "$MSGERR"
  sleep 1s
else # Tell sysadmin that all is well
  echo -e "$MSGOK" | /bin/mail
    -r heartbeat-watcher@example.com
    -s "$MSGOK" sysadmin@example.com
  notify-send-all "$MSGOK"
fi
```

Figure 47: Heartbeat watcher.

Line 311 specifies who is the owner of the upssched process. See table 104 for a list of possible owners.

Line 315 will succeed if there is a process managing the heartbeat.

Lines 317, 318 and 321 show three different ways of telling the sysadmin that all is not well with the heartbeat process. Pick which one(s) suit you. See appendix D for a discussion of notify-send-all.

The Bash script requires something like line 329 in /etc/crontab:

```
1 8 * * * nut /usr/local/bin/heartbeat-watcher.sh > /dev/null 2>&1
```

In this example, line 329 declares that the Bash script is to be run at 08:01 hrs every day as user “nut”. OpenSUSE might use “upsd”. See table 104 for a list of possible users. See also man crontab(5).

This chapter has introduced the timers provided by upssched. We will see in the next chapter that much more can be done with them.
7 Workstation with timed shutdown

All the configurations we have looked at so far have one thing in common. The system shutdown is provoked by UPS status [LB]. This means that when the system finally shuts down, the battery is depleted. It will still be depleted when wall power returns and the system restarts. This is not a problem if the power supply is inherently reliable, and the power supply will continue long enough to recharge the batteries, but this is not always the case. The maintenance people do not always fix the problem completely on their first visit. In neighbourhoods where lightning strikes frequently, where local industrial activity plays havoc with the voltage, and in neighbourhoods with training schools for backhoe operators, we expect the wall power to fail again, and again.

In this chapter the criteria for a system shutdown will not be based on the status [LB], but on the status [OB] and an elapsed time.

It is sometimes said in NUT circles “get the most out of your UPS by hanging on as long as possible”. In this chapter we say “get the most out of your UPS by being able to shut down cleanly as often as possible”.

![Diagram of workstation with timed shutdown](bad.svg)

Figure 48: Workstation with timed shutdown.

Nine configuration files specify the operation of NUT in a workstation with timed shutdown. In this chapter we will give these configuration files in full to avoid excessive page turning.

1. The NUT startup configuration: **nut.conf**. Since this file is not strictly a part of NUT, and is common to all configurations, it is discussed separately in appendix A.
2. The upsd UPS declarations **ups.conf**: See chapter 7.1
3. Configuration file **heartbeat.conf** which defines the dummy UPS providing the heartbeat. See chapter 7.2
4. The upsd daemon access control **upsd.conf**: See chapter 7.3
5. The upsd user declarations **upsd.users**: See chapter 7.4
6. The upsmon daemon configuration: **upsmon.conf**. See chapter 7.5
7. The upssched configuration: **upssched.conf**. See chapter 7.6
8. The upssched-cmd script: see chapter 7.7
9. The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix B.

7.1 Configuration file ups.conf for workstation with timed shutdown

```plaintext
# ups.conf, timed shutdown
[UPS-1]
driver = usbhid-ups
port = auto
desc = "Bigspark ECO 1600"
offdelay = 60
ondelay = 70
lowbatt = 33

[heartbeat]
driver = dummy-ups
port = heartbeat.conf
mode = dummy-loop
desc = "Watch over NUT"
```

Figure 49: Configuration file ups.conf for workstation with timed shutdown.

This configuration file includes support for the heartbeat, and is unchanged from that discussed in the previous chapter. See 6.1

Lines 331 and 338 begin a UPS-specific section, and name the UPS unit that upsd will manage. The following lines provides details for each UPS. There will as many sections as there are UPS units. Make sure this name matches the name in upsmon.conf and in upssched-cmd, which we will meet later.

Lines 332 and 339 specify the driver that upsd will use. For the full list of drivers, see the Hardware Compatibility list and the required drivers at http://www.networkuptools.org/stable-hcl.html.

Lines 333 and 340 depend on the driver. For the usbhid-ups driver the value is always auto. For the dummy-ups driver, the value is the address of the file which specifies the dummy UPS behaviour. This file should be in the same directory as ups.conf. For other drivers, see the man page for that driver.

Line 341 is needed by NUT 2.8.0 to specify that the program of work described by the file heartbeat.conf is to be repeated endlessly. See man dummy-ups.

Lines 334 and 342 provide descriptive texts for the UPS.

For a detailed discussion of offdelay and ondelay on lines 335-336 see chapter 2.7

Additional line 337 sets the default value for battery.charge.low. Even if you use command upsrw to set a value for battery.charge.low, usbhid-ups and some other drivers will restore the default, so if you want a permanent change you must change the default. See also chapter 2.10

---

18 List needed
7.2 Configuration file **heartbeat.conf** for workstation with timed shutdown

Create the new file **heartbeat.conf** in the same directory as **ups.conf**.

```plaintext
# heartbeat.conf
# 10 minute heartbeat
ups.status: OL
TIMER 300
ups.status: OB
TIMER 300
```

Figure 50: This is the configuration file **heartbeat.conf** for a workstation with timed shutdown.

This configuration file provides the definition of the heartbeat, and is unchanged from that discussed in chapter 6.2.

The heartbeat definitions are not provided by NUT, you have to create them yourself. Create the new file **heartbeat.conf** in the same directory as **ups.conf**. For security, only users `nut` and `root` should have write access to this file.

Because it is in mode **dummy-loop**, the dummy UPS will cycle continuously through this script.

Lines 345 and 347 flip the **ups.status** value between `[OL]` and `[OB]`. Lines 346 and 348 place a 5 minute time interval between each status change. Remember that $2 \times 300 \text{sec} = 10 \text{min}$, the heartbeat period.

7.3 Configuration file **upsd.conf** with timed shutdown

```plaintext
# upsd.conf
LISTEN 127.0.0.1 3493
LISTEN ::1 3493
```

Figure 51: Configuration file **upsd.conf** for workstation with timed shutdown.

This configuration file declares on which ports the **upsd** daemon will listen, and provides a basic access control mechanism. It does not change from the version shown on lines 37-38.

Line 350 declares that **upsd** is to listen on it’s preferred port for traffic from the localhost. It is possible to replace 127.0.0.1 by `0.0.0.0` which says “listen for traffic from all sources” and use your firewall to filter traffic to port 3493.

If you do not have IPv6, remove or comment out line 351.

---

19 This is for Debian 11. See table 104 in appendix C for other user names.
7.4 Configuration file `upsd.users` with timed shutdown

This configuration file declares who has write access to the UPS. It does not change from the version shown in lines 40-42. For good security, ensure that only users `nut`\textsuperscript{20} and root can read and write this file.

Line 353 declares the “user name” of the system administrator who has write access to the UPS’s managed by `upsd`. It is independent of `/etc/passwd`. The `upsmon` client daemon will use this name to poll and command the UPS’s.

There may be several names with different levels of access. For this example we only need one.

Line 354 provides the password. You may prefer something better than “sekret”. **Warning:** Avoid placing spaces U+0020 and quotation marks " U+0022 in passwords.

Line 355 declares that this user is the `upsmon` daemon, and the required set of actions will be set automatically. In this simple configuration daemon `upsmon` is a `primary`.

The configuration file for `upsmon` must match these declaration for `upsmon` to operate correctly.

For lots of details, see `man upsd.users`.

7.5 Configuration file `upsmon.conf` with timed shutdown

The previous chapters have repeatedly modified `upsmon.conf` so we provide here a complete description of the file, including all previous modifications.

This configuration file declares how `upsmon` is to handle NOTIFY events. For good security, ensure that only users `nut`\textsuperscript{21} and root can read and write this file.

On line 357

- The UPS name `UPS-1` must correspond to that declared in `ups.conf` line 331.
- The “power value” 1 is the number of power supplies that this UPS feeds on this system.
- `nut-admin` is the “user” declared in `upsd.users` line 353.
- `sekret` is the password declared in `upsd.users` line 354.

\textsuperscript{20} This is for Debian 11. See table 104 in appendix C for other user names.

\textsuperscript{21} This is for Debian 11. See table 104 in appendix C for other user names.
primary means this system will shutdown last, allowing any secondaries time to shutdown first. There are no secondaries in this simple configuration.

Line 358 declares that upsmon is also to monitor the heartbeat.

On line 359, MINSUPPLIES sets the number of power supplies that must be receiving power to keep this system running. Normal computers have just one power supply, so the default value of 1 is acceptable. See man upsmon.conf and file big-servers.txt in the NUT documentation for more details.

<table>
<thead>
<tr>
<th>Line</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>360</td>
<td><code>SHUTDOWNCMD &quot;/sbin/shutdown -h +0&quot;</code></td>
</tr>
<tr>
<td>361</td>
<td><code>NOTIFYCMD /usr/sbin/upssched</code></td>
</tr>
<tr>
<td>362</td>
<td><code>POLLFREQ 5</code></td>
</tr>
<tr>
<td>363</td>
<td><code>POLLFREQALERT 5</code></td>
</tr>
<tr>
<td>364</td>
<td><code>DEADTIME 15</code></td>
</tr>
<tr>
<td>365</td>
<td><code>POWERDOWNFLAG /etc/killpower</code></td>
</tr>
</tbody>
</table>

Figure 54: Configuration file upsmon.conf with timed shutdown, part 2 of 5.

Line 360 declares the command to be used to shut down the server. A second instance of the upsmon daemon running as root will execute this command. Multiple commands are possible, for example `SHUTDOWNCMD "logger -t upsmon.conf \"SHUTDOWNCMD calling /sbin/shutdown to shut down system\" ; /sbin/shutdown -h +0"` will also log the action of `SHUTDOWNCMD`. Note that internal " have to be escaped. Note also that this command will be used in any call to `upsmon -c fsd`. See line 429.

Line 361 says which program is to be invoked when upsmon detects a NOTIFY event flagged as EXEC. The example shown is for Debian 11, sysadmins for other distributions should check the directory used.

Line 362 `POLLFREQ`, declares that the upsmon daemon will poll upsd every 5 seconds.

Line 363 `POLLFREQALERT`, declares that the upsmon daemon will poll upsd every 5 seconds while the UPS is on battery.

Line 364 `DEADTIME` specifies how long upsmon will allow a UPS to go missing before declaring it “dead”. The default is 15 seconds.

Daemon upsmon requires a UPS to provide status information every few seconds as defined by POLLFREQ and POLLFREQALERT. If the status fetch fails, the UPS is marked stale. If it stays stale for more than DEADTIME seconds, the UPS is marked dead.

A dead UPS that was last known to be on battery [OB] is assumed to have changed to a low battery condition [OB]→[OB LB]. This may force a shutdown. Disruptive, but the alternative is barreling ahead into oblivion and crashing when you run out of power. See chapter 3.3 for more discussion.

Line 365 `POWERDOWNFLAG` declares a file created by upsmon when running in primary mode when the UPS needs to be powered off. It will be used in more complex configurations. See man upsmon.conf for details.
Lines 366-375 assign a text message to each NOTIFY event. Within each message, the marker %s is replaced by the name of the UPS which has produced this event. upsmon passes this message to program wall to notify the system administrator of the event. You can change the default messages to something else if you like. The format is NOTIFYMSG event "message" where %s is replaced with the identifier of the UPS in question. Note that program wall has not been internationalized and does not support accented letters or non latin characters. When the corresponding NOTIFYFLAG contains the symbol EXEC, upsmon also passes the message to the program specified by NOTIFYCMD on line 361.

Lines 376-385 declare what is to be done at each NOTIFY event. The declarations, known as ‘flags’ are shown in table 14. You may specify one, two or three flags for each event, in the form FLAG[,+FLAG]*, however IGNORE must always be alone.

Lines 376-377 carry only the EXEC flag: Since the heartbeat induces a lot of [ONLINE] and [ONBATT] traffic, the SYSLOG option would flood the log and WALL would put far too many useless messages in xterm windows. When the NOTIFY event occurs, EXEC declares that upsmon should call the program identified by the NOTIFYCMD on line 361.

Note that if you have multiple UPS’s, the same actions are to be performed for a given NOTIFY event for all the UPS’s. Clearly this is not good news.
When a UPS says that it needs to have its battery replaced, upsmon will generate a [REPLBATT] NOTIFY event. Line 386 say that this happens every RBWARNTIME = 43200 seconds (12 hours).

Line 387: Daemon upsmon will trigger a [NOCOMM] NOTIFY event after NOCOMMWARNTIME seconds if it can’t reach any of the UPS entries in configuration file upsmon.conf. It keeps warning you until the situation is fixed.

Line 388: When running in primary mode, upsmon waits this long after sending the [SHUTDOWN] NOTIFY event to warn the users. After the timer elapses, it then runs your SHUTDOWNCMD as specified on line 360. If you need to let your users do something in between those events, increase this number. Don’t make this too big, even though the battery still has charge. Alternatively, you can set this very low so you don’t wait around when it’s time to shut down.

For lots and lots of details, see man upsmon.conf. See also the file config-notes.txt in the distribution.

7.6 Configuration file upssched.conf with timed shutdown

The NOTIFY events detected by upsmon and flagged as EXEC in upsmon.conf become events for upssched when NOTIFYCMD points to upssched. The program upssched provides a richer set of actions than upsmon, especially the management of timers.

```plaintext
# upssched.conf PIPEFN, LOCKFN for Debian 11
CMDSCRIPT /usr/bin/upssched-cmd
PIPEFN /run/nut/upssched.pipe
LOCKFN /run/nut/upssched.lock
```

On line 390 CMDSCRIPT points to a user script to be called for designated NOTIFY events. The value shown is for Debian 11. Ubuntu sysadmins might see /usr/local/bin/upssched-script. This script will receive as argument a user chosen timer name.

Line 391 defines PIPEFN which is the file name of a socket used for communication between upsmon and upssched. It is important that the directory be accessible to NUT software and nothing else. I recommend that you use the same directory as is used for communication between upsd and the drivers. Search for the directory which contains the file upsd.pid. You should see at least one socket. See for example the footnote to section 1.3.1

The value shown on line 391 is for the Debian 11 distribution which places upsd.pid in directory /run/nut/. As always, sysadmins for other distributions should check the directory used. You should see an additional entry in the directory:
Daemon `upsmon` requires the `LOCKFN` declaration on line 392 to avoid race conditions. The directory should be the same as `PIPEFN`.

### 7.6.1 The `AT` declaration

```verbatim
394 AT ONBATT UPS-1@localhost START-TIMER two-minute-warning-timer 5
395 AT ONBATT UPS-1@localhost START-TIMER one-minute-warning-timer 65
396 AT ONBATT UPS-1@localhost START-TIMER shutdown-timer 125
397
398 AT ONLINE UPS-1@localhost CANCEL-TIMER two-minute-warning-timer
399 AT ONLINE UPS-1@localhost CANCEL-TIMER one-minute-warning-timer
400 AT ONLINE UPS-1@localhost CANCEL-TIMER shutdown-timer
401 AT ONLINE UPS-1@localhost EXECUTE ups-back-on-line
402
403 AT ONBATT heartbeat@localhost CANCEL-TIMER heartbeat-failure-timer
404 AT ONBATT heartbeat@localhost START-TIMER heartbeat-failure-timer 660
```

Figure 59: Configuration file `upssched.conf` with timed shutdown, part 2.

Line 394 introduces the very useful `AT` declaration provided by `upssched.conf`. This has the form

```
AT notifytype UPS-name command
```

where

- `notifytype` is a symbol representing a NOTIFY event.
- `UPS-name` can be the special value “*” to apply this handler to every possible value of `UPS-name`. We strongly recommend that you do not use this wildcard, since we need distinct actions for distinct UPS’s.
- The `command` values are `START-TIMER`, `CANCEL-TIMER` and `EXECUTE`.

Line 394 says what is to be done by `upssched` for event `[ONBATT]`. The field “UPS-1@localhost” says that it applies to the UPS we are using, and the `START-TIMER` says that `upssched` is to create and manage a timer called “two-minute-warning-timer” which runs for 5 seconds. When this timer completes, `upssched` calls the user script specified by `CMDSCRIPT` with argument “two-minute-warning-timer”.

Lines 395 and 396 do the same thing for the 65 second timer `one-minute-warning-timer` and the 125 second timer `shutdown-timer`.
Line 398 says what is to be done by upssched for event [ONLINE]. The field “UPS-1@localhost” says that it applies to the UPS we are using, and the CANCEL-TIMER says that upssched must cancel the timer “two-minute-warning-timer”. The user script is not called.

Lines 399 and 400 do the same thing for the 65 second timer “one-minute-warning-timer” and the 125 second timer “shutdown-timer”.

Line 401 command EXECUTE says that upssched is to call the user script immediately with the argument “ups-back-on-line”.

On line 403 when upssched receives an [ONBATT] it executes the command which is CANCEL-TIMER heartbeat-failure-timer. This kills the timer. upssched does not call the user script.

Immediately afterwards, on line 404, and for the same [ONBATT] event, upssched executes the command START-TIMER heartbeat-failure-timer 660 which restarts the heartbeat-failure-timer which will run for 660 sec, i.e. 11 minutes. If the timer completes, upssched will call the user script upssched-cmd with parameter heartbeat-failure-timer.

7.7 Script upssched-cmd for workstation with timed shutdown

```bash
#!/bin/bash -u
# upssched-cmd Workstation with heartbeat and timed shutdown
logger -i -t upssched-cmd Calling upssched-cmd $1

# Send emails to/from these addresses
EMAIL_TO="sysadmin@example.com"
EMAIL_FROM="upssched-cmd@${HOSTNAME:-nut}.example.com"

UPS="UPS-1"
STATUS=$( upsc $UPS ups.status )
CHARGE=$( upsc $UPS battery.charge )

CHMSG="[$STATUS]:$CHARGE%"
```

Figure 60: Configuration script upssched-cmd for timed shutdown, 1 of 2.

The user script upssched-cmd, the example is in Bash, manages the completion of the timers two-minute-warning-timer, one-minute-warning-timer, shutdown-timer, ups-back-on-line and heartbeat-failure-timer. Here is an complete example of what can be done. You will probably need to modify this for your own use. Note that this script could be written in the language of your choice, as long as the resulting program is able to receive the timer names as a parameter, send e-mails and log and notify the users of messages. Bash has the advantage of being widely available and is understood by many sysadmins.

On lines 409 and 410 change the e-mail addresses to something that works for you.

Lines 411-414 prepare a Bash variable CHMSG which gives the current UPS status and battery charge. This is to be included in messages, so we get a clearer idea of what is happening.
Figures 61: Configuration script `upssched-cmd` for timed shutdown, 2 of 2.

Lines 416-422 introduce the `heartbeat-failure-timer` case into the case statement. Line 417 specifies a message to be logged with the current UPS status as defined on lines 411-414. Lines 418-420 compose a message to the sysadmin which is sent on line 421. The message includes the current state of those NUT kernel processes which are operational.

### 7.7.1 The timed shutdown

The cases at lines 423 and 425 specify warnings to be notified to the users when the `two-minute-warning-timer` and `one-minute-warning-timer` complete.

Beginning at line 427 we prepare a message which the user may not see, since we call for an immediate shutdown. The UPS may well be almost fully charged, but the shutdown is now, leaving enough charge for further shutdowns in the near future.

Note on line 429 that we use `upsmon` to shut down the system. This automatically takes into account any secondary systems which need to be shut down as well. The command `upsmon -c fsd` will call the command specified by the `SHUTDOWNCMD` declaration on line 360.

Line 430 prepares a message that `notify-send-all` will put in front of the users to tell them to get back to work since wall power has returned. See appendix D for a discussion of `notify-send-all`. 
7.8 The timed shutdown story

We now tell the detailed story of how the workstation gets shut down when wall power fails, and how it restarts when wall power returns.

1. Wall power on  The system runs normally. upsdf status is [OL]. No NOTIFY event.
   
   Days, weeks, months go by...

2. Wall power fails  The workstation remains operational running on the UPS battery. upsdf polls the UPS, and detects status change [OL]→[OB].

3. upsmon polls upsdf, receives status [OB] and issues NOTIFY event [ONBATT]. As instructed by line 377 upsmon calls upssched, specified by NOTIFYCMD on line 361 Note that there is no wall message and no logging by upsmon.

4. upssched matches the NOTIFY event [ONBATT] and the UPS name UPS-1@localhost with the three AT specifications on lines 394-396  Three timers start: two-minute-warning-timer, one-minute-warning-timer and shutdown-timer, managed in memory by upssched.
   
   5 seconds go by...

5. two-minute-warning-timer completes, and upssched calls the user script upssched-cmd specified by CMDSCRIPT on line 390 with the timer name as argument. In the script, this matches the case on line 423 which defines a suitable warning message in Bash variable MSG. Line 435 logs this message and line 436 puts it in front of the users. The workstation continues to operate on battery power.
   
   60 seconds go by...

6. one-minute-warning-timer completes, and upssched calls the user script upssched-cmd with the timer name as argument. In the script, this matches the case on line 425 which defines a stronger warning message in Bash variable MSG. Line 435 logs this message and line 436 puts it in front of the users. The workstation continues to operate on battery power.
   
   60 seconds go by...

7. shutdown-timer completes, and upssched calls the user script upssched-cmd with the timer name as argument. In the script, this matches the case on line 427 which defines an ultimate warning message in Bash variable MSG, and then calls upsmon for a system shutdown. Line 435 logs message MSG and line 436 puts it in front of the users. The workstation continues to operate on battery power during the shutdown. If wall power returns, it is now too late to call off the shutdown procedure.

8. upsmon commands a system shutdown and generates NOTIFY event [SHUTDOWN].

9. upsmon waits FINALDELAY seconds as specified on line 388.

10. upsmon creates POWERDOWN flag specified on line 365

11. upsmon calls the SHUTDOWNCMD specified on line 360
12. We now enter the scenario described in figure 16. The operating system’s shutdown process takes over. During the system shutdown, the Bash script shown in figure 17 or equivalent systemd service unit or some other equivalent runs the command `upsdrvctl shutdown`. This tells the UPS that it is to shut down `offdelay` seconds later as specified on line 335.

13. The system powers down, hopefully before the `offdelay` seconds have passed.

14. **UPS shuts down** `offdelay` seconds have passed. With some UPS units, there is an audible “clunk”. The UPS outlets are no longer powered.

   *Minutes, hours, days go by...*

15. **Wall power returns** Some time later, maybe much later, wall power returns. The UPS reconnects it’s outlets to send power to the protected system.

16. The system BIOS option “restore power on AC return” has hopefully been selected and the system powers up. The bootstrap process of the operating system begins.

17. The operating system starts the NUT daemons `upsd` and `upsmon`. Daemon `upsd` scans the UPS and the status becomes `[OL]`. We are now back in the same situation as state 1 above.

18. We hope that the battery has retained sufficient charge to complete further timed shutdown cycles, but if it hasn’t, then at the next power failure, `upsd` will detect the status `[OB LB]`, `upsmon` will receive status `[OB LB]` and issue a `[LOWBATT]` and will begin the system shutdown process used by the simple server of chapter 2. This system shutdown will override any `upssched` timed process.
8 Workstation with additional equipment

The time has come to look at a more ambitious configuration, with multiple UPS's and multiple computer systems. NUT has been designed as an assembly of components each performing a distinct part of the operation. We now see that this design allows NUT to adapt and perform well in complex configurations.

The configuration is for an industrial application in which some undisclosed industrial equipment is protected by a UPS (UPS-3), and is also driven by a computer system having it’s own UPS (UPS-2). This equipment with the driving computer is at a remote site, code name gold. Overall management is from a computer at a different, administrative site. We will call the management system mgmt.

Computer mgmt is represented here as if it were a single machine, but it could well be duplicated at different sites for reliability. Two (or more) mgmt systems may monitor a single gold production machine.

Fourteen configuration files specify the operation of NUT in the production and management machines.
1. **gold**: The NUT startup configuration: `nut.conf`. This file is not strictly a part of NUT, and is common to all configurations. See chapter 8.1 and appendix A.

2. **gold**: The `upsd` UPS declarations `ups.conf`: See chapter 8.2.

3. **gold**: The `upsd` daemon access control `upsd.conf`: See chapter 8.3.

4. **gold**: The `upsd` user declarations `upsd.users`: See chapter 8.4.

5. **gold**: The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix B. The shutdown script for the undisclosed device is beyond the scope of this text.

6. **mgmt**: The NUT startup configuration: `nut.conf`. This file is not strictly a part of NUT, and is common to all configurations. See chapter 8.1 also appendix A.

7. **mgmt**: The `upsd` UPS declarations `ups.conf`: See chapter 8.2.

8. **mgmt**: The `upsd` heartbeat declaration `heartbeat.conf`: See chapter 8.2.

9. **mgmt**: The `upsd` daemon access control `upsd.conf`: See chapter 8.3.

10. **mgmt**: The `upsd` user declarations `upsd.users`: See chapter 8.4.

11. **mgmt**: The `upsmon` daemon configuration `upsmon.conf`: See chapter 8.5.

12. **mgmt**: The `upssched` configuration `upssched.conf`: See chapter 8.6.

13. **mgmt**: The `upssched-cmd` script: See chapter 8.7.

14. **mgmt**: The delayed UPS shutdown script. Since this file is common to all configurations, it is discussed separately in appendix B.

### 8.1 Configuration files `nut.conf`

The first configuration files say which parts of the NUT are to be started.

```plaintext
437 # nut.conf -- gold --
438 MODE=netserver

439 # nut.conf -- mgmt --
440 MODE=standalone
```

Figure 63: File `nut.conf` for **gold**.

Figure 64: Files `nut.conf` for **mgmt**.

Strictly speaking, this file is not for NUT, but for the process which starts NUT. The initialization process is expected to source this file to know which parts of nut are to be started. Some distributions, e.g. openSUSE, ignore this file and start the three NUT layers `driver`, `upsd` and `upsmon`. They assume that `MODE=standalone`.

This is probably satisfactory for **mgmt**, but for **gold** you should review line 438 and the init/systemd startup of the NUT software to ensure that only the `upsd` and `driver` daemons get started. See appendix A. See also `man nut.conf`
8.2 Configuration files \texttt{ups.conf} and \texttt{heartbeat.conf}

These configuration files declare which UPS’s are to be managed by the instances of NUT.

\textbf{gold}:

\begin{verbatim}
441 # ups.conf -- gold --
442 [UPS-3]
443     driver = usbhid-ups
444     port = auto
445     desc = "Huge 3 phase"
446     offdelay = 20
447     ondelay = 30
448     lowbatt = 33
449     serial = 00328
450
451 [UPS-2]
452     driver = usbhid-ups
453     port = auto
454     desc = "Small monophase"
455     offdelay = 20
456     ondelay = 30
457     lowbatt = 33
458     serial = XT766
\end{verbatim}

Figure 65: File \texttt{ups.conf} for \texttt{gold}.

\textbf{mgmt}:

\begin{verbatim}
459 # ups.conf -- mgmt --
460 [UPS-1]
461     driver = usbhid-ups
462     port = auto
463     desc = "BigSpark ECO 1600"
464     offdelay = 60
465     ondelay = 70
466     lowbatt = 33
467
468 [heartbeat]
469     driver = dummy-ups
470     port = heartbeat.conf
471     mode = dummy-loop
472     desc = "Watch over NUT"
\end{verbatim}

Figure 66: File \texttt{ups.conf} for \texttt{mgmt}.

\begin{verbatim}
473 # heartbeat.conf -- 10 min
474 ups.status: OL
475 TIMER 300
476 ups.status: OB
477 TIMER 300
\end{verbatim}

Figure 67: \texttt{heartbeat.conf} for \texttt{mgmt}.

\textbf{gold}:

On lines 442-451 we offer specimen definitions for UPS-3 and UPS-2. You will need to review these to take into account the UPS’s you are using. Lines 452 and 443 specify the drivers that \texttt{upsd} will use. For the full list of drivers, see the Hardware Compatibility list and the required drivers at \url{http://www.networkupstools.org/stable-hcl.html}.

The \texttt{offdelay} and \texttt{ondelay} on lines 446-447 and 455-456 are given their default values. You may need something different. See the discussion in chapter 2.5 of the delayed UPS shutdown.

In order to distinguish the two USB attached UPS units on \texttt{gold}, we specify their serial numbers on lines 449 and 458. See \texttt{man usbhid-ups}.

\textbf{mgmt}:

On lines 460-465 we offer a specimen definition for UPS-1 and on lines 474-477 we propose the dummy UPS “heartbeat” discussed in chapter 6. The heartbeat requires the definition file \texttt{heartbeat.conf}, lines 474-477, to be placed in the same directory as \texttt{ups.conf}. 

8.3 Configuration files \texttt{upsd.conf}

This configuration file declares on which ports the \texttt{upsd} daemon will listen, and provides a basic access control mechanism. You will need a secure means of accessing \texttt{gold} from \texttt{mgmt}. This could be for example through an SSH tunnel or over a VPN. The limited access defined by the \texttt{LISTEN} directive is part of a defense in depth.

\texttt{gold}: Line 479 declares that \texttt{upsd} is to listen on a preferred port for traffic from \texttt{mgmt}. The example is for the \texttt{tun0} interface of an OpenVPN secure network. See \url{https://openvpn.net/}. It is possible to specify 0.0.0.0 which says “listen for traffic from all sources” and use your firewall to filter traffic to port 3493. You must modify lines 479 and 480 for your own needs.

\texttt{mgmt}: Line 482 declares that \texttt{upsd} is to listen on its preferred port for traffic from the localhost. It is possible to replace 127.0.0.1 by 0.0.0.0 which says “listen for traffic from all sources” and use your firewall to filter traffic to port 3493.

If you do not have IPv6, remove or comment out lines 480 and 483. See \texttt{man upsd.conf} for more detail, and a description of the OpenSSL support.

8.4 Configuration files \texttt{upsd.users}

This configuration file declares who has write access to the UPS. The “user name” used in these files is independent of \texttt{/etc/passwd}. For good security, ensure that only users \texttt{nut}\footnote{This is for Debian 11. See table \texttt{104} in appendix \texttt{C} for other user names.} and root can read and write this file. The configuration files for \texttt{upsmon} must match these declarations for \texttt{upsmon} to operate correctly.

For lots of details, see \texttt{man upsd.users}.

\texttt{gold}: Line 485 declares the “user name” of the system administrator who has write access to UPS-2 and UPS-3 managed by \texttt{upsd}. The \texttt{upsmon} client daemon in \texttt{mgmt} will use this name to poll and command the UPS’s.

Line 486 provides the password. You may prefer something better than “sekret”. \textbf{Warning:} Avoid placing spaces \texttt{U+0020} and quotation marks “ \texttt{U+0022} in passwords.
Line 487 declares the type of relationship between the `upsd` daemon on `gold` and the `upsmon` in `mgmt` which has the authority to shutdown `gold`. The declaration “`upsmon secondary`” would allow monitoring but not shutdown. See `man upsmon.users` See also `man upsmon` section UPS DEFINITIONS, but our configuration is not exactly what that man page refers to.

`mgmt`: Line 489 declares the “user name” of the system administrator who has write access to UPS-1 and to the heartbeat managed by `upsd`.

Line 490 provides another `uberl33t` password.

Line 491 declares the type of relationship between the `upsd` daemon and `upsmon` which has the authority to shutdown `mgmt`.

### 8.5 Configuration file `upsmon.conf`

The previous chapters have repeatedly modified `upsmon.conf` so we provide here a complete description of the file.

```plaintext
492 # upsmon.conf -- mgmt --
493 MONITOR UPS-3@gold 0 nut-admin sekret primary
494 MONITOR UPS-2@gold 0 nut-admin sekret primary
495 MONITOR UPS-1=localhost 1 nut-admin sekret primary
496 MONITOR heartbeat=localhost 0 nut-admin sekret primary
497 MINSUPPLIES 1
```

Figure 72: Configuration file `upsmon.conf` for `mgmt`, part 1 of 5.

This configuration file declares how `upsmon` in `mgmt` is to handle NOTIFY events from `gold` and from `mgmt` itself. For good security, ensure that only users `nut` and root can read and write this file.

Line 493 specifies that `upsmon` on `mgmt` will monitor UPS-3 which supplies power to the undisclosed device.

- The UPS name **UPS-3** must correspond to that declared in `ups.conf` line 456
- The “power value” 1 is the number of power supplies that this UPS feeds on the local system. A “power value” of 0 means that the UPS-3 does not supply power to `mgmt`.
- **nut-admin** is the “user” declared in `upsd.users` line 485
- **sekret** is the `uberl33t` password declared in `upsd.users` line 486
- **primary** means this system will shutdown last, allowing any secondaries time to shutdown first. There are no secondaries on `gold`.

Line 494 specifies that `upsmon` on `mgmt` will also monitor UPS-2 which supplies the `gold` computer.

23This is for Debian 11. See table 104 in appendix C for other user names.
Line 495 specifies that \texttt{upsmon} on \texttt{mgmt} will monitor \texttt{UPS-1} which supplies power to \texttt{mgmt} itself. Note the “power value” of 1.

Line 496 declares that \texttt{upsmon} is also to monitor the heartbeat.

On line 497, \texttt{MINSUPPLIES} sets the number of power supplies that must be receiving power to keep the \texttt{mgmt} system running. A lot of computers have just one power supply, so the default value of 1 is acceptable. See \texttt{man upsmon.conf} and file \texttt{big-servers.txt} in the NUT documentation for more details.

\begin{verbatim}
498 SHUTDOWNCMD "/sbin/shutdown -h +0"
499 NOTIFYCMD /usr/sbin/upssched
500 POLLFREQ 5
501 POLLFREQALERT 5
502 DEADTIME 15
503 POWERDOWNFLAG /etc/killpower
\end{verbatim}

Figure 73: Configuration file \texttt{upsmon.conf} for \texttt{mgmt}, part 2 of 5.

Line 498 declares the command to be used to shut down \texttt{mgmt}. A second instance of the \texttt{upsmon} daemon running as root on \texttt{mgmt} will execute this command. Multiple commands are possible, for example \texttt{SHUTDOWNCMD "logger -t upsmon.conf \"SHUTDOWNCMD calling /sbin/shutdown to shut down system\" ; /sbin/shutdown -h +0"} will also log the action of \texttt{SHUTDOWNCMD}. Note that internal " have to be escaped. Note also that any calls of the command \texttt{upsmon -c fsd} will also execute this command. See line 576.

The shutdown command for \texttt{gold} is not specified in \texttt{upsmon.conf}. It appears in the user script \texttt{upssched-cmd} in chapter 8.7.

Line 499 says which program is to be invoked when \texttt{upsmon} detects a NOTIFY event flagged as \texttt{EXEC}.

Line 500 \texttt{POLLFREQ}, declares that the \texttt{upsmon} daemon will poll \texttt{upsd} in \texttt{gold} and in \texttt{mgmt} every 5 seconds.

Line 501 \texttt{POLLFREQALERT}, declares that the \texttt{upsmon} daemon will poll the \texttt{upsd} daemons every 5 seconds while any UPS in on battery.

Line 502 \texttt{DEADTIME} specifies how long \texttt{upsmon} will allow a UPS to go missing before declaring it “dead”. The default is 15 seconds.

Daemon \texttt{upsmon} requires a UPS to provide status information every few seconds as defined by \texttt{POLLFREQ} and \texttt{POLLFREQALERT}. If the status fetch fails, the UPS is marked stale. If it stays stale for more than \texttt{DEADTIME} seconds, the UPS is marked dead.

A dead \texttt{UPS-1} that was last known to be on battery \texttt{[OB]} is assumed to have changed to a low battery condition \texttt{[OB]}\texttt{[OB LB]}. This may force a shutdown of \texttt{mgmt}. Disruptive, but the alternative is barreling ahead into oblivion and crashing when you run out of power. See chapter 3.3 for more discussion.

Line 503 \texttt{POWERDOWNFLAG} declares a file created by \texttt{upsmon} when running in primary mode when \texttt{UPS-1} needs to be powered off. See \texttt{man upsmon.conf} for details.
Lines 504-513 assign a text message to each NOTIFY event. Within each message, the marker \texttt{%s} is replaced by the name of the UPS which has produced this event. On \texttt{mgmt upsmon} passes this message to program \texttt{wall} to notify the system administrator of the event. You can change the default messages to something else if you like. The format is \texttt{NOTIFYMSG \textit{event} "message"} where \texttt{%s} is replaced with the identifier of the UPS in question. Note that program \texttt{wall} has not been internationalized and does not support accented letters or non latin characters. When the corresponding \texttt{NOTIFYFLAG} contains the symbol \texttt{EXEC}, \texttt{upsmon} also passes the message to the program specified by \texttt{NOTIFYCMD} on line 499.

Lines 514-523 declare what is to be done at each NOTIFY event. The declarations, known as ‘flags’ are shown in table 14. You may specify one, two or three flags for each event, in the form \texttt{FLAG[+FLAG]*}, however \texttt{IGNORE} must always be alone.

Lines 514-515 carry only the \texttt{EXEC} flag: Since the heartbeat induces a lot of [ONLINE] and [ONBATT] traffic, the \texttt{SYSLOG} option would flood the log and \texttt{WALL} would put far too many useless messages in xterm windows. When the NOTIFY event occurs, \texttt{EXEC} declares that \texttt{upsmon} should call the program identified by the \texttt{NOTIFYCMD} on line 499.

Note that if you have multiple UPS’s, the same actions are to be performed for a given NOTIFY event for all the UPS’s. Once again, we see that this is not good news.
524  
525  
526  

Figure 76: Configuration file upsmon.conf for mgmt, part 5 of 5.

When a UPS says that it needs to have its battery replaced, upsmon will generate a [REPLBATT] NOTIFY event. Line 524 say that this happens every RBWARNTIME = 43200 seconds (12 hours).

Line 525: Daemon upsmon will trigger a [NOCOMM] NOTIFY event after NOCOMMWARNTIME seconds if it can’t reach any of the UPS entries in configuration file upsmon.conf. It keeps warning you until the situation is fixed.

Line 526: When running in primary mode, upsmon waits this long after sending the [SHUTDOWN] NOTIFY event to warn the users. After the timer elapses, it then runs your SHUTDOWN CMD as specified on line 498. If you need to let your users do something in between those events, increase this number. Don’t make this too big, even though the battery still has charge. Alternatively, you can set this very low so you don’t wait around when it’s time to shut down.

For lots and lots of details, see man upsmon.conf See also the file config-notes.txt in the distribution.

8.6 Configuration file upssched.conf for mgmt

Daemon upsmon in mgmt detects the NOTIFY events due to status changes in gold and in mgmt, and for those flagged as EXEC in upsmon.conf calls upssched as indicated by the NOTIFYCMD directive. The program upssched provides a richer set of actions than upsmon, especially the management of timers.

On line 528 CMDSCRIPT points to a user script to be called for designated NOTIFY events. This script will receive as argument the user chosen timer name.

Line 530 defines PIPEFN which is the file name of a socket used for communication between upsmon and upssched. It is important that the directory be accessible to NUT software and nothing else. For line 530 the Debian distribution uses /var/run/nut/upssched.pipe.

Daemon upsmon requires the LOCKFN declaration on line 531 to avoid race conditions. The directory should be the same as PIPEFN.

8.6.1 UPS-3 on gold

Lines 533 and 534 say what is to be done by upssched for a NOTIFY event [ONBATT] due to UPS-3 on gold. On line 533 the START-TIMER says that upssched is to create and manage a timer called “UPS-3-two-minute-warning-timer” which runs for 5 seconds. When this timer completes, upssched calls the user script specified by CMDSCRIPT with argument “UPS-3-two-minute-warning-timer”. Line 534 does a similar thing for the 125 second timer “UPS-3-shutdown-timer”.

Hopefully the back-up generator starts, and power returns before 2 minutes have gone by. Lines 535-537 say what is to be done by upssched for NOTIFY event [ONLINE]. The CANCEL-TIMER
# upssched.conf -- mgmt --
CMDSCRIPT /usr/bin/upssched-cmd

# PIPEFN LOCKFN suitable for Debian 11
PIPEFN /run/nut/upssched.pipe
LOCKFN /run/nut/upssched.lock

```
AT ONBATT UPS-3@gold      START-TIMER UPS-3-two-minute-warning-timer 5
AT ONBATT UPS-3@gold      START-TIMER UPS-3-shutdown-timer 125
AT ONLINE UPS-3@gold      CANCEL-TIMER UPS-3-two-minute-warning-timer
AT ONLINE UPS-3@gold      CANCEL-TIMER UPS-3-shutdown-timer
AT ONLINE UPS-3@gold      EXECUTE UPS-3-back-on-line

AT ONBATT UPS-2@gold      START-TIMER UPS-2-two-minute-warning-timer 5
AT ONBATT UPS-2@gold      START-TIMER UPS-2-shutdown-timer 125
AT ONLINE UPS-2@gold      CANCEL-TIMER UPS-2-two-minute-warning-timer
AT ONLINE UPS-2@gold      CANCEL-TIMER UPS-2-shutdown-timer
AT ONLINE UPS-2@gold      EXECUTE UPS-2-back-on-line

AT ONBATT UPS-1@localhost START-TIMER UPS-1-two-minute-warning-timer 5
AT ONBATT UPS-1@localhost START-TIMER UPS-1-shutdown-timer 125
AT ONLINE UPS-1@localhost CANCEL-TIMER UPS-1-two-minute-warning-timer
AT ONLINE UPS-1@localhost CANCEL-TIMER UPS-1-shutdown-timer
AT ONLINE UPS-1@localhost EXECUTE UPS-1-back-on-line

AT ONBATT heartbeat@localhost CANCEL-TIMER heartbeat-failure-timer
AT ONBATT heartbeat@localhost START-TIMER heartbeat-failure-timer 660
```

Figure 77: Configuration file `upssched.conf` for mgmt.

declarations say that `upssched` must cancel the timers “UPS-3-two-minute-warning-timer” and “UPS-3-shutdown-timer”. The user script is not called.

Line 537 command EXECUTE says that `upssched` is to call the user script immediately with the argument “UPS-3-back-on-line”.

8.6.2 UPS-2 on gold

UPS-2 on gold is handled in exactly the same way as UPS-3. Lines 539 and 540 define the timers which start when `upssched` receives a NOTIFY event [ONBATT], and lines 541 and 542 cancel those timers when hopefully `upssched` receives NOTIFY event [ONLINE].

Line 543 command EXECUTE says that `upssched` is to call the user script immediately with the argument “UPS-2-back-on-line”.

8.6.3 UPS-1 on mgmt

UPS-1 on mgmt is also handled in exactly the same way as UPS-3. Lines 545 and 546 define the timers which start when upssched receives a NOTIFY event [ONBATT], and lines 547 and 548 cancel those timers when hopefully upssched receives NOTIFY event [ONLINE], however if power does not return before two minutes have gone by, the timer “UPS-1-shutdown-timer” will complete and upssched will call the user script with the parameter “UPS-1-shutdown-timer”.

Line 549 command EXECUTE says that upssched is to call the user script immediately with the argument “UPS-1-back-on-line”.

8.6.4 heartbeat on mgmt

On line 551, when daemon upssched receives an [ONBATT] it executes the command CANCEL-TIMER heartbeat-failure-timer. This kills the timer. upssched does not call the user script.

Immediately afterwards, on line 552 and for the same [ONBATT] event, upssched executes command START-TIMER heartbeat-failure-timer 660 which restarts the heartbeat-failure-timer which will run for another 660 sec, i.e. 11 minutes. If the timer completes, upssched will call the user script upssched-cmd with parameter “heartbeat-failure-timer”.

8.7 User script upssched-cmd

```bash
#!/bin/bash -u
# upssched-cmd -- mgmt --
logger -i -t upssched-cmd Calling upssched-cmd $1

# Send emails to/from these addresses
EMAIL_TO=sysadmin@example.com
EMAIL_FROM=upssched-cmd@$HOSTNAME-nut.example.com

function make-STCH {
    STCH="[\$( upsc $1 ups.status )]:\$( upsc $1 battery.charge )%"
}

```

Figure 78: User script upssched-cmd on mgmt, 1 of 5.

The user script upssched-cmd, the example we show is in Bash, manages the completion of UPS-3-two-minute-warning-timer, UPS-2-two-minute-warning-timer, UPS-1-two-minute-warning-timer, UPS-3-shutdown-timer, UPS-2-shutdown-timer, UPS-1-shutdown-timer, UPS-3-back-on-line, UPS-2-back-on-line, UPS-1-back-on-line and heartbeat-failure-timer.

There is no such thing as a single script which fits all industrial situations, but here is an example of what can be done. You will probably need to modify this for your own use. Note that this script could be written in the language of your choice, as long as the resulting program is able to receive
the timer names as a parameter, send e-mails and log and notify the users of messages. Bash has
the advantage of being widely available and is understood by many sysadmins.

In figure 78 on lines 558 and 559, change the e-mail addresses to something that works for you.

Lines 561-562 declare a function which prepares a Bash variable \texttt{STCH} which gives the current
UPS status and battery charge. This is to be included in messages, so we get a clearer idea of what
is happening.

The bulk of the user script is a case statement beginning at line 563 covering all the possible
parameter values (timer names) that the user script may expect.

564 (UPS-3-two-minute-warning-timer) make-STCH UPS-3@gold
565 MSG="UPS-3: gold power failure. $STCH" ;;
566 (UPS-3-shutdown-timer) make-STCH UPS-3@gold
567 MSG="UPS-3: gold shutdown. $STCH" ;;
568 Command for undisclosed device shutdown, e.g. saltstack
569 (UPS-3-back-on-line) make-STCH UPS-3@gold
570 MSG="UPS-3: power returns. $STCH" ;;

571 Case “UPS-2” is very similar

Figure 79: User script \texttt{upssched-cmd} on \texttt{mgmt}, 2 of 5.

In figure 79, lines 564-570 cover the events associated with \texttt{UPS-3 on gold}. When an \texttt{[ONBATT]}
occurs the sysadmin receives \texttt{wall} and \texttt{notify} warnings that power to the undisclosed device has
failed, and that unless alternative power becomes available in two minutes, the undisclosed device
will be shut down. These warnings contain the text assembled in Bash variable \texttt{MSG}. Additionally,
when the \texttt{[ONBATT]} occurs \texttt{upssched} begins a two minute timer \texttt{UPS-3-shutdown-timer}. If no
alternative power appears, and this timer expires, the installation specific code on line 568 will
shut down the undisclosed device attached to \texttt{gold}. This code might for example be based on the
\texttt{saltstack} remote management tools.

572 (UPS-1-two-minute-warning-timer) make-STCH UPS-1
573 MSG="UPS-1: gold power failure. $STCH" ;;
574 (UPS-1-shutdown-timer) make-STCH UPS-1
575 MSG="UPS-1: gold shutdown. $STCH"
576 /usr/sbin/upsmon -c fsd ;;
577 (UPS-1-back-on-line) make-STCH UPS-1
578 MSG="UPS-1: power returns. $STCH" ;;

Figure 80: User script \texttt{upssched-cmd} on \texttt{mgmt}, 3 of 5.

In figure 80 lines 572-578 cover the events associated with \texttt{UPS-1 on mgmt}. When an \texttt{[ONBATT]}
occurs the sysadmin receives \texttt{wall} and \texttt{notify} warnings that power to the management workstation
has failed, and that unless alternative power becomes available in two minutes, the workstation will
be shut down. These warnings contain the text assembled in Bash variable \texttt{MSG}. Additionally, when
the [ONBATT] occurs upssched begins a two minute timer UPS-1-shutdown-timer. If no alternative power appears, and this timer expires, the command upsmon -c fsd on line 576 will shut down the workstation by executing the command specified by SHUTDOWNCMD on line 498.

```plaintext
(heartbeat-failure-timer)  make-STCH heartbeat
  MSG="NUT heartbeat fails. $STCH" ;;
  MSG1="Hello, upssched-cmd reports NUT heartbeat has failed."
  MSG2="Current status: $STCH 

  $0 $1"
  MSG3="\n\n$0 $( ps -elf | grep -E 'ups[dms]|nut' )"
  echo -e "$MSG1 $MSG2 $MSG3" | /bin/mail -r "$EMAIL_FROM" 
  -s "NUT heartbeat fails. Currently $CHMSG" "$EMAIL_TO" ;;
```

Figure 81: User script upssched-cmd on mgmt, 4 of 5.

In figure 81 lines 579-585 cover the event associated with heartbeat on mgmt. The “heartbeat” technique is discussed in detail in chapter 6. If the heartbeat-failure-timer completes then something is wrong with NUT, and lines 581, 582 and 583 prepare a message for the sysadmin in Bash variables MSG1, MSG2 and MSG3. Lines 584-585 e-mail the message to the sysadmin. The message includes the current state of those NUT kernel processes which are operational.

```plaintext
(*) logger -i -t upssched-cmd "Bad arg: "$1", $CHMSG"
  exit 1 ;;
  esac
  logger -i -t upssched-cmd $MSG
  notify-send-all "$MSG"
```

Figure 82: User script upssched-cmd on mgmt, 5 of 5.

In figure 82 lines 586-587 cover any unexpected parameter values, and lines 589-590 log the message and pass it to the system notification.
8.8 The shutdown story

UPS-3 on gold: If UPS-3 detects that power has failed, and takes over the supply to the undisclosed device, then the NUT setup will advise the system administrator on the mgmt workstation. If the backup generator comes on automatically before two minutes, then the sysadmin on mgmt will be informed, but if power does not re-appear, then script upssched-cmd in mgmt will remotely command the “shutdown” of the undisclosed device. A complete shutdown may be impossible, and all that can be done for some equipment is to put it into a quiescent state. The management workstation mgmt is not shut down.

UPS-2 on gold: If UPS-2 detects that its own power supply has failed, and that it is now powering gold, then the NUT setup of this chapter will advise the system administrator on the mgmt workstation. With the example configuration, if power is not restored in two minutes then an action in the script upssched-cmd will shut down both gold and the undisclosed device. Workstation mgmt is not shut down.

UPS-1 on mgmt: If UPS-1 detects that its own power supply has failed, and the workstation management is now on battery power, then we enter the scenario described in detail in chapter 7. There is no need to shutdown the undisclosed device or gold. A backup workstation on a different site could take over the management of UPS-3 and UPS-2.
9 Introduction

The description of the Python3 scripts in this Part supposes that you have some experience as a system administrator and that you are already familiar with NUT, it’s component daemons and configuration files as described in Part 1.

9.1 Use of Python3

9.1.1 No object orientation

The Python language was originally designed in the apparent belief that all would be OO, but this is now weakening\textsuperscript{24} as one writer put it «in order to attract a larger audience».

The Python3 scripts are not “object oriented” (OO). NUT itself is a process control application and is “event oriented”, not “object oriented”. The Python scripts of part 2 are similarly “event oriented”, and the design will be evident to those familiar with the NUT C code.

The Python scripts proposed for NUT provide a set of functions, and a main program written in an imperative style — very similar to the NUT C programs. The coding syntax itself is influenced by the OO origins of Python. For example the concatenation of two strings \(a\) and \(b\) is written '\.join([a, b])'. In OO parlance the class of the empty string \(''\) provides the method \texttt{join} with a list of parameters. However no OO skill or conviction is needed to read the proposed scripts.

9.1.2 Lint-free code

The Python3 scripts described in this documentation are “lint free” as determined by the \texttt{pylint} program which follows the PEP 8 style guide for Python code. Since the Python3 programs described here are a contribution to NUT rather than the general Python ecosystem, changes have been made

\textsuperscript{24}See Object-Oriented Programming — The Trillion Dollar Disaster, Ilya Suzdalnitski.
### Global changes from default in pylintrc

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indentation string reduced from 4 to 2 spaces.</td>
</tr>
<tr>
<td>2</td>
<td>Allow lines up to 132 characters instead of 100.</td>
</tr>
<tr>
<td>3</td>
<td>Disabled the undefined-variable option. This looks like a pylint bug.</td>
</tr>
<tr>
<td>4</td>
<td>Disabled the bad-whitespace, bad-continuation, multiple-statements and broad-except options.</td>
</tr>
<tr>
<td>5</td>
<td>Removed statistical reports from output.</td>
</tr>
<tr>
<td>6</td>
<td>Comment out the deprecated option “symbols”.</td>
</tr>
<tr>
<td>7</td>
<td>Option include-naming-hint is turned on.</td>
</tr>
<tr>
<td>8</td>
<td>Option max-module-lines increased from 1000 to 4000.</td>
</tr>
<tr>
<td>9</td>
<td>Options module-rgx and module-naming-hint changed. Modules may have names of form [a-zA-Z][a-zA-Z0-9]*]</td>
</tr>
<tr>
<td>10</td>
<td>Option variable-rgx allows uppercase letters. Variables may have names of the form [a-zA-Z_][a-zA-Z0-9_]{2,30}]</td>
</tr>
<tr>
<td>11</td>
<td>Option const-rgx allows lowercase letters. Constants may have names of the form (([a-zA-Z_][a-zA-Z0-9_]*]</td>
</tr>
</tbody>
</table>

### Local changes from default included in code

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td># pylint: disable=global-statement Python PEP 8 dislikes the use of global variables. We find simple and effective use, and inhibit the warning.</td>
</tr>
<tr>
<td>13</td>
<td># pylint: disable=anomalous-backslash-in-string This warning is a Pylint false positive.</td>
</tr>
<tr>
<td>14</td>
<td># pylint: disable=undefined-loop-variable Pylint dislikes \texttt{\texttt{var = var + ...}</td>
</tr>
</tbody>
</table>

Figure 83: File pylintrc, Changes to the default Python style.

to allow NUT characteristics to be freely expressed. These changes to the default Python style are defined by file pylintrc, and shown in figure 83.

The PEP 8 style guide for Python code requires that no line include trailing spaces. To remove trailing spaces using emacs, try command \texttt{M-x replace-regexp RET }\texttt{{$}} \texttt{RET RET} where }\texttt{{}} is a space. How does vim do this? The \texttt{l33t} use command :\texttt{:%s/\s\+$//e}
10 \textbf{mkNUTcert.py builds TLS certificates}

A secure network connection between the Attachment Daemon and the Management Daemon requires use of TLS (Transport Layer Security) public and private keys. TLS replaces its now-deprecated predecessor, Secure Sockets Layer (SSL) used by release 2.7.4 \texttt{upsd} and \texttt{upsmon}. Building keys which meet the increasingly complex requirements of the Internet is not obvious. The Python3 utility script \texttt{mkNUTcert.py} described here builds a TLS private key for a server such as \texttt{upsd}, a self-signed CA certificate and a certificate for a client such as \texttt{upsmon} that wishes to access the server. The status is “experimental”. The script is optimised for use with NUT and is expected to be run on the same machine as \texttt{upsd}. It is intended for demonstration and experiment. The license is GPL v3 or later at your choice, with support in the \texttt{nut-upsuser} mailing list.

10.1 Very Short Introduction to TLS Certificates

SSL and the TLS that has replaced SSL are a quagmire of technical terms many of which are out-of-date, confusing or incorrectly used. The OpenSSL project has produced a Swiss Army Knife\textsuperscript{25} of utilities which are the best known tools for work in this area. Anyone venturing into this mess has to do a lot of reading. Here is a very short list.

- The Network UPS Tools User Manual, chapter 9, Notes on securing NUT.
- The NUT man pages \texttt{man upsd.conf} and \texttt{man upsmon.conf}.
- The command \texttt{openssl help} followed by \texttt{openssl command -help} for details of the options offered by the \texttt{command} tool.
- The \texttt{openssl man page} and it’s copious “See Also”.
- Ivan Ristić’s “A Short Guide to the Most Frequently Used OpenSSL Features and Commands” available at web site feistyduck.com \texttt{OpenSSL Cookbook}.
- Web site digitalocean.com, \texttt{OpenSSL Essentials: Working with SSL Certificates, Private Keys and CSRs}.
- Website how2ssl.com, \texttt{OpenSSL tips and common commands}.

Here is a short summary of technical terms used in this chapter, see also this post.

\textbf{Certificate} A file containing the public key used by clients to communicate with the server, possibly with additional information. For public keys we use file names of the form \texttt{mybox-client.cert.pem} where \texttt{mybox} is the name of the \texttt{upsd} server.

\textsuperscript{25}I counted 48 tools in version 1.1.0f.
Certificate Authority (CA) Commercial businesses and others who want their customers to feel safe using their sites have their TLS certificates verified by a Certificate Authority (CA). You apply with a Certificate Signing Request (CSR), pay and receive a copy of your certificate linked to a trusted root certificate, for some meaning of “trust”.

Where does NUT stand? We are our own Certificate Authority and the certificate we create is itself the root certificate. We do not use CSRs. We trust ourselves. In a closed industrial context where few people have access to the systems, this provides better security than the commercial offerings used on the web. Quoting from RFC 5280, section 3.2:

(a) Certification paths start with a public key of a CA in a user’s own domain, or with the public key of the top of a hierarchy. Starting with the public key of a CA in a user’s own domain has certain advantages. In some environments, the local domain is the most trusted.

Root certificate A Certifying Authority takes the private key and provides a certificate of authenticity known as a “root certificate”. However in the commercial world intermediaries appear and get paid to add their certificates, thus forming a “chain of trust”. NUT does not have such a chain. The root certificate is the only one. In NUT’s self-signed world, the upsd server uses as private key a file which contains the private key and then the root certificate[26] For the private key we use a file name of the form mybox.cert.pem where mybox is the name of the upsd server. The clients will use just the root certificate which contains the public key.

PEM PEM is an encoding[27] format for a certificate which is already ASN1 encoded and which allows it to be included in “ascii” base 64 files. If you are curious, the three letters PEM stand for Privacy-enhanced Electronic Mail. We use file type .cert.pem for these certificate files, but you will also find such certificates with just the pem extension.

CSR A Certificate Signing Request contains the private key and the additional information needed to build the public key certificate. A CSR is needed for public sites for which an expensive external service will sign the certificate as authentic and valid (for some value of authentic and valid). Since UPS units are not a public matter, we sign our own certificates. NUT does not use CSR’s.

---

[26] In that order. See figure 85

[27] Historically, this encoding was used for early networks which only guaranteed to transmit 7 of the 8 bits in a byte.
10.2 Overview of mkNUTcert.py

The script has many options, but in general few and in some simple cases none at all are needed. To see the options and their default values enter command `mkNUTcert.py --help`

```bash
$ mkNUTcert.py --help
usage: mkNUTcert.py [-h] [-SAN <list of server names>]
                   [-C <ISO 3166 two letters>] [-O <name>] [-OU <unit name>]
                   [--serialNumber <integer>] [--notBefore <integer>]
                   [--notAfter <integer>] [-s <filename>] [-c <filename>] [-v]
```

Figure 84: Command `mkNUTcert.py --help`.

Let’s look at these optional arguments in more detail.

--clientcertfile `<filename>`, -c `<filename>` File path and name for the client’s certificate. `mkNUTcert.py` tries to guess where to put things. Lucky Debian users might see `/etc/nut/mybox-client.cert.pem`. All the clients of the `upsd` server use this certificate.

--countryName `<ISO 3166 two letters>`, -C `<ISO 3166 two letters>` Please feel free to specify your 2 digit ISO 3166 Country Codes. The default is “FR”.

-h, --help show this help message and exit

-O `<name>`, --organisationName `<name>` The proud default for organisation name is “Network UPS Tools”. You probably don’t have to change this.

-OU `<unit name>`, --organisationUnitName `<unit name>` The default value for the Organisation Unit name is “mkNUTcert.py version 1.1”. Again, you probably don’t have to change this.

--serialNumber `<integer>` The default for the serial number is 1.

--servercertfile `<filename>`, -s `<filename>` File path and name for the server's certificate. `mkNUTcert.py` tries to guess where to put things. Lucky users of Debian might see `/etc/nut/mybox.cert.pem`. See table 104 for a list of possible directories.

--subjectAltName `<list of server names>`, -SAN `<list of server names>` You may well want to change this option. It defines a space separated list of names of the `upsd` server. The default is “`mybox localhost 10.218.0.19 mybox.example.com`” where `mybox` is the name of the machine on which you have run `mkNUTcert.py`. In earlier releases of SSL/TLS the option CN (Common Name) was used to specify the server name. This is now deprecated in favour of SAN (subjectAltName).
--notAfter <integer> The validity end time in seconds from now. The default is 0, i.e. indefinite validity. Note that the value specified in the certificate is Dec 31 23:59:59 9999 GMT as required by RFC 5280 para 4.1.2.5

--notBefore <integer> The validity start time is seconds from the moment you run the program. The default is 0, i.e. now. You probably don’t have to change this.

-v, --version Show mkNUTcert.py, Python and SSL/TLS versions, then exit.

10.3 What mkNUTcert.py provides

The private key and public keys, known as certificates) provided by mkNUTcert.py are in the form of PEM encoded files:

- Root certificate mybox.cert.pem
- Public certificate mybox-client.key.pem

10.3.1 Private Key and Certificate = Root Certificate

The server’s root certificate, i.e. private key with a self-signed certificate, PEM encoding can be seen with command shown on line 596 in figure 85.

This file, like the root certificate, should be protected. It should have very restricted ownership and permissions.

```
596 $ grep -A1 -E "^-" /etc/nut/titan.cert.pem
597 -----BEGIN PRIVATE KEY-----
598 MIJQwIBADANBgkqhkiG9w0BAQEFAAASCCSowggkpAgEAAoICAQC2sJigLVujiJO/
599 --
600 -----END PRIVATE KEY-----
601 -----BEGIN CERTIFICATE-----
602 MIIFDQAwIBAgIBAdIBA2AgIBATANBgkqhkiG9w0BAQQFADBMMQswCQYDVQQGEwJGUjEa
603 --
604 -----END CERTIFICATE-----
```

Figure 85: Root certificate = private key and certificate.

If you attempt to display the contents of the root certificate using the command openssl x509 -text -noout -in /etc/nut/titan.cert.pem then only the certificate is displayed, as shown in figure 87.
10.3.2 Public Key Certificate

The client’s public key certificate contains the public key and certifies\footnote{A public key certificate provides a safe way for an entity to pass on its public key to be used in asymmetric cryptography. The public key certificate avoids the following situation: if Charlie creates his own public key and private key, he can claim that he is Alice and send his public key to Bob. See techtarget.com} that it is indeed the public key corresponding to the \texttt{upsd} server’s private key. It contains only a \texttt{CERTIFICATE} part, not the \texttt{PRIVATE KEY} part. The PEM encoding can be seen with command shown on line 605 in figure 86:

```bash
605 root@titan ~ grep -A1 -E "^---" /etc/nut/titan-client.cert.pem
606 -----BEGIN CERTIFICATE-----
607 MIIFhDCCA2ygAwIBAgIBATANBgkqhkiG9w0BAQQFADBMMQswCQYDVQQGEwJGUjEa
608 --
609 -----END CERTIFICATE-----
```

Figure 86: The client’s PEM encoded public certificate.

Details of the certificate can be seen with the command shown on line 610 in figure 87 which shows a self-signed public certificate:

1. The certificate is certified directly by the server’s root certificate and there are no intermediate certificates. NUT acts as it’s own certifying authority. For tightly controlled situations such as UPS management, this provides better security.
2. The certificate is self-signed. The issuer on line 616 is also the subject on line 620 as required by RFC 5280 para 4.1.2.4 last sentence.
3. The value “Dec 31 23:59:59 9999 GMT” on line 619 is defined by RFC 5280 para 4.1.2.5.
4. The public key begins on line 625.
5. There is no Authority Key Identifier which is obligatory for Web certificates. This omission is specific to self-signed certificates, see RFC 5280 para 4.2.1.1.
Figure 87: The self-signed public certificate.
10.4 Running `mkNUTcert.py`

1. Before running the script, check the shebang `#!` in the first line. The default value is `#!/usr/bin/python3 -u`. Check that you have a sufficiently recent version of Python3 at that address. If your version is not sufficiently recent, you will receive an error message from `mkNUTcert.py`. How do I know if I have a sufficiently recent version of Python3? Try running the script. If it runs, you’re ok. Otherwise you will need to upgrade your Python installation.

2. Run command `mkNUTcert.py --help` to see the default values. Pay extra attention to the following:

<table>
<thead>
<tr>
<th>Option</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--subjectAltName</code></td>
<td><code>host localhost 10.218.0.19 host.example.com</code></td>
</tr>
<tr>
<td><code>--servercertfile</code></td>
<td><code>Script-tries-to-guess/host.cert.pem</code></td>
</tr>
<tr>
<td><code>--clientcertfile</code></td>
<td><code>Script-tries-to-guess/host.client.cert.pem</code></td>
</tr>
</tbody>
</table>

The script also attempts to guess the owner:group for the two output files. You should review that choice.

3. When you run the command `mkNUTcert.py` you will be reminded of the proposed file paths and file names for the certificates. Enter “yes” to confirm and anything else to exit immediately. If you continue, `mkNUTcert.py` will report:

```plaintext
638 Writing private key with self-signed certificate for server to file ... 
639 This file must be protected. E.g. do not make it world readable.
640 Current owner is nut:nut with permissions 0o600.
641
642 Writing user certificate for client to file ...
643 The user (i.e. client) certificate should be installed in all monitors.
644 Current owner is nut:nut with permissions 0o644.
```

4. Ensure that the private key and the root certificate are properly protected. Only root and the user designated to run `upsd` should have access to the private key. No-one else.

   The root certificate is given restrictive permissions 600. If you attempt to run the script a second time it may well refuse if there is already a root certificate at the same address with such restrictive permissions. You have to remove the old root certificate yourself as user root. Take care!

   The user (i.e. the client) certificate is given permissions 644.

5. Transfer the user certificate to the machine(s) running the Management Daemon, e.g. `upsmon`. Check that ownership and permissions are correct on the destination machine.
11 Encrypted connections

The configurations we have seen so far assume that the connection between the NUT client and the NUT server is either in the same machine or over a local, well protected network. The client’s password is transmitted in clear text to the server. This may be a reasonable risk locally, but is not acceptable if client and server are connected by a public network or by a network deemed to be at risk. This chapter looks at the technique for encrypting the traffic between client and server made possible by TLS 1.3 support in NUT 2.8.0.

Chapter 12 discusses the use of TLS shims to provide the same encryption for NUT 2.7.4.

See chapter 10.1 for a very short introduction to the quagmire of technical terms many of which are confusing or incorrectly used.

This chapter will continue the habit of chapter 8 of referring to the server to which the UPS is connected as gold and the management client as mgmt.
11.1 Additional configuration files

In addition to the configuration files discussed in previous chapters, the following configuration files are also needed for encrypted communication between remote NUT server `gold` and management client `mgmt`.

11.1.1 In the remote server “gold”

Add the following lines to `upsd.conf`. See `man upsd.conf`

```plaintext
# upsd.conf
... 
DISABLE_WEAK_SSL true
CERTFILE /etc/nut/titan.cert.pem
```

Line 647 prevents use of insecure early versions of SSL/TLS by restricting `upsd` to use TLSv1.2 or better.

On line 648 the `upsd` daemon access control `upsd.conf` needs the private key generated by `mkNUTcert.py`. The `CERTFILE` declaration declares the file containing the root certificate, i.e. the private key and the certificate in PEM format. See chapter 10.3.1.

11.1.2 In each management client “mgmt”

Add the following lines to `upsmon.conf`. See `man upsmon.conf`

```plaintext
# upsmon.conf
... 
CERTVERIFY 1
CERTPATH /etc/nut/titan-client.cert.pem
```

Line 651 makes `upsmon` verify all connections with certificates. Without this, there is no guarantee that the `upsd` is the right host. Enabling this greatly reduces the risk of man-in-the-middle attacks. This effectively forces the use of SSL, so don’t use this unless all of your `upsd` hosts are ready for SSL and have their certificates in order.

In line 652 `CERTPATH` points to a file containing a certificate in PEM format, used to verify the server certificate presented by the `upsd` server.

---

29 The name “CERTFILE” is a poor choice since it is a private key not a public key. A name such as “KEYFILE” would have been better. Normally it is public keys that are referred to as “certificates”.

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Debugging: Sniffing port 3493

Testing is essential to achieve the required level of security, and a key part of this testing is sniffering
the network to ensure that the connections to port 3493 on the NUT server gold are indeed encrypted.

We use tcpdump on Debian for this testing. Other network sniffering software is available. The
first test is to see the clear text nature of the non-encrypted communication.

1. In the server, gold, or in the management client mgmt, run the command tcpdump -A port
   nut as root.
2. In the management client mgmt, stop upsmon, and then restart it with the command
   systemctl restart nut-monitor.service.
3. tcpdump will display the trace shown in figure 89 which has been edited to make it easier
to read. Line 657 shows the client mgmt attempting to begin an encrypted session which is
refused by server gold on line 659. Line 663 shows the password transmitted in clear text.
Let this be a warning to you.

   Lines 669-672: Client mgmt then makes a plain text request every 5 seconds for the status
   of UPS-3 which the server gold then answers in plain text.

```
653 listening on wlan0, link-type EN10MB (Ethernet), capture size 262144 bytes
654 IP mgmt.33656 > gold.nut:  
655 IP gold.nut > mgmt.33656:  
656 IP mgmt.33656 > gold.nut:  
657 IP mgmt.33656 > gold.nut: STARTTLS  
658 IP gold.nut > mgmt.33656:  
659 IP gold.nut > mgmt.33656: ERR FEATURE-NOT-CONFIGURED  
660 IP mgmt.33656 > gold.nut:  
661 IP mgmt.33656 > gold.nut: USERNAME upsmaster  
662 IP gold.nut > mgmt.33656: OK  
663 IP mgmt.33656 > gold.nut: PASSWORD sekret  
664 IP gold.nut > mgmt.33656: OK  
665 IP mgmt.33656 > gold.nut: LOGIN UPS-3  
666 IP gold.nut > mgmt.33656: OK  
667 IP mgmt.33656 > gold.nut: MASTER UPS-3  
668 IP gold.nut > mgmt.33656: OK MASTER-GRANTED  
669 IP mgmt.33656 > gold.nut: GET VAR UPS-3 ups.status  
670 IP gold.nut > mgmt.33656: VAR UPS-3 ups.status "OL"  
671 IP mgmt.33658 > gold.nut:  
672 IP mgmt.33656 > gold.nut: GET VAR UPS-3 ups.status  
673 IP gold.nut > mgmt.33656: VAR UPS-3 ups.status "OL"
```

Figure 89: tcpdump of systemctl start nut-monitor.service without encryption.
11.3 Testing the TLS setup

This test was done using a hybrid setup in which a version 2.8.0 `upsmon` talks to a version 2.7.4 `upsd` equipped with a shim `upsdTLS.py`. As shown in figure 92 `upsd` listens on customary port 3493 (nut), but the shim is listening on port 401.

First we trace the unencrypted traffic on port 3493 (nut). The trace has been edited to make it easier to read:

```
 674 ~ tcpdump -i any port 3493 -c 2 -A
 675 ...
 676 IP mgmt.53634 > gold.nut: GET VAR UPS-3 ups.status
 677 IP gold.nut > mgmt.53634: VAR UPS-3 ups.status "OL"
```

Figure 90: Unencrypted traffic on port 3493 (nut).

And now the same message exchange but on port 401:

```
 678 ~ tcpdump -i any port 401 -c 2 -A
 679 ...
 680 IP mgmt.41248 > gold.401: *...5Q.W.2..U.&..!......i..~...j......%..Q~
 681 IP gold.401 > mgmt.41248: +6...&..u....6.F6.h.R................G5..1Y
```

Figure 91: Encrypted traffic on port 401.
12 Shim daemons `upsdTLS.py` and `upsmonTLS.py`

The NUT project is now mature and proceeds at cautious speed. The SSL/TLS features of release 2.7.4 became obsolete and were deprecated before the next release 2.8.0 appeared. The [RFC 9271](http://tools.ietf.org/html/rfc9271) proposed to address this security problem with a pair of TLS support shims sitting one beside `upsd` and the other in the client system.

This chapter describes an experimental implementation of the shims in of the scripts `upsdTLS.py` and `upsmonTLS.py`. The scripts and their SHA1 check sums may be downloaded from [http://rogerprice.org/NUT](http://rogerprice.org/NUT)

![Command flow](upsdTLS.svg)

Figure 92: NUT 2.7.4 TLS support using shims `upsdTLS.py` and `upsmonTLS.py`.

NUT 2.7.4 did not support the latest versions of TLS. This prevented NUT 2.7.4 from using TLS since TLS strongly deprecates use of earlier versions which are no longer considered secure. To overcome this difficulty, Python script `upsdTLS.py` provides a shim to help `upsd` work with the latest, and most secure, versions of TLS. `upsdTLS.py` runs as a daemon alongside `upsd` receiving TLS encrypted traffic from its companion shim `upsmonTLS.py` or from a TLS enabled client such as UPSmon.py and passing on that traffic to local `upsd` using an unencrypted socket. The script’s status is "experimental!", and is intended for demonstration and experiment. It must run on the same machine as `upsd`. The license is GPL v3 or later at your choice, with support in the [nut-upsuser mailing list](mailto:).  

### 12.1 Overview of Shim `upsdTLS.py`

The script has no configuration files, but has many options. In general few and in some simple cases none at all are needed. To see the options and their default values you can enter command

```
upsdTLS.py --help
```

Let’s look at these optional arguments in more detail. XXX

```
--backlog <integer> Maximum incoming message backlog, default value 5. You should not usually need to change this.
```
-D, --debug Increase the debugging level, may be repeated but then you get more than any human can read. Debugging output is written into the NUT log file.

-h, --help Show this help message and exit

--listen <IPv4_address> <port_number> upsdTLS.py listens to (i.e. receives commands from) shim upsmontLS.py or a TLS enabled client on this interface and port, with the default '127.0.0.1' 401. Temporarily, we squat IANA 401/tcp (ups). Setting a port number < 1024 requires starting the daemon as root.

--listentimeout <float> Socket timeout for exchanges on the port specified by --listen. The default is 5.0 seconds.

-l <file>, --logfile <file> The log file, with default /var/log/NUT.log. Progress and error messages and the copious stuff generated by option --D go into this file. See chapter E for an extension to logrotate to cover this file.

--maxconn <integer> Maximum number of incoming connections, the default is 10. Strictly speaking, the maximum number of sockets the daemon process may have open, where getconf OPEN_MAX gives system file maximum. You should not usually need to change this.

--PIDfile <file> The child PID is written into this file, for the greater pleasure of systemd. The default for upsdTLS.py is /run/nut/upsdTLS.pid. Do not change this unless you know what you are doing. You should also review the systemd service unit.

-s <file>, --servercertfile <file> The file path and file name of the server’s private key. upsdTLS.py tries to guess where to put things. The default on Debian systems is /etc/nut/mybox.cert.pem. OpenSUSE sysadmins would probably use /etc/ups/... See table 104 for a list of possible directories.

-u <user>, --user <user> After launch as root, run as this user. upsdTLS.py tries to guess the user. OpenSUSE admins would probably see upsd, whereas Debian admins would see nut. See table 104 for a list of possible users.

--upsdport <integer> Relay incoming commands to this upsd port, and (no surprise) the default relay port to upsd is 3493. upsd is assumed to be running on localhost.
--upsdtimeout <float>  Socket timeout for exchanges with upsd. The default is 5.0 seconds.

-v, --version  Show program, Python and SSL/TLS versions, then exit.

12.2  Overview of Shim upsmonTLS.py

The script has no configuration files, but lots of options. In general few and in some simple cases none at all are needed. To see the options and their default values you can enter command upsmonTLS.py --help.

Let’s look at these optional arguments in more detail.

--backlog <integer>  Maximum incoming message backlog, default value 5. You should not usually need to change this.

-c <file>, --clientcertfile <file>  The file path and file name of the client’s certificate (public key). upsmonTLS.py tries to guess where to put things. The default on Debian systems is /etc/nut/mybox-client.cert.pem. OpenSUSE sysadmins would probably use /etc/ups/... See table 104 for a list of possible directories.

-D, --debug  Increase the debugging level, may be repeated but then you get more than any human can read. Debugging output is written into the NUT log file.

-h, --help  Show this help message and exit

--listen <IPv4_address>  upsmonTLS.py listens to the client such as upsmon or upsc on this interface and port, with the default '127.0.0.1' 3493

--listentimeout <float>  Socket timeout for exchanges on the port specified by --listen. The default is 5.0 seconds.

-l <file>, --logfile <file>  The log file, with default /var/log/NUT.log. Progress and error messages and the copious stuff generated by option -D go into this file. See chapter E for an extension to logrotate to cover this file.
--maxconn <integer> Maximum number of incoming connections, the default is 10. Strictly speaking, the maximum number of sockets the daemon process may have open, where getconf OPEN_MAX gives system file maximum. You should not usually need to change this.

--PIDfile <file> The child PID is written into this file, for the continuing pleasure of systemd. The default for upsmonTLS.py is /run/nut/upsmonTLS.pid Do not change this unless you know what you are doing. You should also review the systemd service unit.

-u <user>, --user <user> After launch as root, run as this user. upsTLS.py tries to guess the user. OpenSUSE admins would probably see ups, whereas Debian admins would see nut. See table 104 for a list of possible users.

--upsdname <domain> Relay incoming commands from the client to the system running the shim upsTLS.py. For example --upsdname "bigserver.example.com". The default name is localhost.

--upsdport <integer> Relay incoming commands from upsmon, upsc, etc. to this ups/shim port. The default relay port for upsmonTLS.py is 401 which the companion script upsTLS.py listens to by default. Temporarily, we squat IANA 401/tcp (ups). Setting a port number < 1024 requires starting the daemon as root.

--upsdtimeout <float> Socket timeout for exchanges with ups. The default is 5.0 seconds.

-v, --version Show program, Python and SSL/TLS versions, then exit.
12.3 Summary of shims `upsdTLS.py` and `upsmonTLS.py`

<table>
<thead>
<tr>
<th><code>upsdTLS.py</code> and <code>upsmonTLS.py</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--backlog &lt;integer&gt;</code></td>
</tr>
<tr>
<td><code>--debug</code></td>
</tr>
<tr>
<td><code>--help</code></td>
</tr>
<tr>
<td><code>--listentimeout &lt;float&gt;</code></td>
</tr>
<tr>
<td><code>--logfile &lt;file&gt;</code></td>
</tr>
<tr>
<td><code>--maxconn &lt;integer&gt;</code></td>
</tr>
<tr>
<td><code>--upsdtimeout &lt;float&gt;</code></td>
</tr>
<tr>
<td><code>--user &lt;user&gt;</code></td>
</tr>
<tr>
<td><code>--version</code></td>
</tr>
</tbody>
</table>

**upsdTLS.py only**

<table>
<thead>
<tr>
<th>Command</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--listen &lt;IPv4&gt; &lt;port&gt;</code></td>
<td>127.0.0.1 401</td>
</tr>
<tr>
<td><code>--PIDfile &lt;file&gt;</code></td>
<td><code>/run/nut/upsdTLS.pid</code></td>
</tr>
<tr>
<td><code>--servercertfile &lt;file&gt;</code></td>
<td><code>/etc/nut/mybox.cert.pem</code></td>
</tr>
<tr>
<td><code>--upsdport &lt;port&gt;</code></td>
<td>3493</td>
</tr>
</tbody>
</table>

**upsmonTLS.py only**

<table>
<thead>
<tr>
<th>Command</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--clientcertfile &lt;file&gt;</code></td>
<td><code>/etc/nut/mybox-client.cert.pem</code></td>
</tr>
<tr>
<td><code>--listen &lt;IPv4&gt; &lt;port&gt;</code></td>
<td>127.0.0.1 3493</td>
</tr>
<tr>
<td><code>--PIDfile &lt;file&gt;</code></td>
<td><code>/run/nut/upsmonTLS.pid</code></td>
</tr>
<tr>
<td><code>--upsdname &lt;domain&gt;</code></td>
<td>localhost</td>
</tr>
<tr>
<td><code>--upsdport &lt;port&gt;</code></td>
<td>401</td>
</tr>
</tbody>
</table>

Figure 95: Summary of `upsdTLS.py` and `upsmonTLS.py` options and default values.

12.4 Running the shims `upsdTLS.py` and `upsmonTLS.py`

The daemons `upsdTLS.py` and `upsmonTLS.py` usually start with user root and fork to run as the same user as `upsd`.

If you use systemd to manage your boxes, then you will need to create new service units, since systemd is unable to start two forking services from the same unit. See `man systemd.service(5)`. There can only be one `Type=forking` per unit.

In the box running `upsd` create a new file by copying the service unit file `/usr/lib/systemd/system/nut-server.service` to `/etc/systemd/system/nut-py-server-shim.service` and modify the new file as shown in figure 96 where lines 694-696 and 698-699 have been changed.
[Unit]
Description=Network UPS Tools - nut-server TLS shim support daemon
After=local-fs.target network.target nut-server.service
Before=nut-py-client.service

[Service]
ExecStart=/usr/sbin/upsdTLS.py
PIDfile=/run/nut/upsdTLS.pid
Type=forking

[Install]
WantedBy=multi-user.target

Figure 96: systemd service unit `nut-py-server-shim.service` for `upsdTLS.py`.

In the box running `upsmon` copy the service unit file `/usr/lib/systemd/system/nut-monitor.service` to `/etc/systemd/system/nut-py-client-shim.service` and modify the new file as shown in figure 97 where lines 704-706 and 708-709 have been changed.

The PIDfile declarations are there to help systemd find the daemon since `upsdTLS.py` and `upsmonTLS.py` do not keep the parent process running when they fork. Note that systemd service units in `/etc` take precedence over those in `/usr/lib`. See `man systemd.unit(5)`.

[Unit]
Description=Network UPS Tools - TLS shim support daemon for nut clients
After=local-fs.target network.target nut-server.service\nut-py-server-shim.service
Before=nut-client.service

[Service]
ExecStart=/usr/sbin/upsmonTLS.py
PIDfile=/run/nut/upsmonTLS.pid
Type=forking

[Install]
WantedBy=multi-user.target

Figure 97: systemd service unit `nut-py-client-shim.service` for `upsmonTLS.py`.

You may choose to place the `upsdTLS.py` and `upsmonTLS.py` scripts in directory `/usr/sbin` or make `/usr/sbin/upsdTLS.py` and `/usr/sbin/upsmonTLS.py` links to wherever you put the Python scripts. After you have made the changes, you should run the command `systemctl daemon-reload` See `man systemctl(1)`.
12.4.1 Enabling the shims *upsdTLS.py* and *upsmonTLS.py*

Before running the shims the first time, you will need to run the command

```bash
systemctl enable nut-py-server-shim.service nut-py-client-shim.service
```

The following `systemctl` commands will be of use to you:

- **systemctl daemon-reload**
  to make any changes to the service unit available to systemd.

- **systemctl enable nut-py-server-shim.service**
  **systemctl enable nut-py-client-shim.service**
  to make the daemons *upsdTLS.py* and *upsmonTLS.py* operational and “startable”.

- **systemctl start nut-py-server-shim.service**
  **systemctl start nut-py-client-shim.service**
  to start *upsdTLS.py* and *upsmonTLS.py*. Note that this will not erase the log file. If you want to clear the log file then you need to do that yourself. See also chapter E for a discussion of log rotation.

- **systemctl status nut-py-server-shim.service**
  **systemctl status nut-py-client-shim.service**
  to see the current status of the shims.

- **systemctl stop nut-py-server-shim.service**
  **systemctl stop nut-py-client-shim.service**
  to stop *upsdTLS.py* and *upsmonTLS.py*.

*upsdTLS.py* and *upsmonTLS.py* should start automatically when the system starts, but they can also be stopped and started manually with the `systemctl` commands.

Serious errors will prevent the shims from starting and you can read about them in the NUT log and in the system log. After starting the shims, check the NUT log for warnings and other error messages.
### 12.4.2 Listing the systemd activity

During the debugging of the shims, I saw a summary of the NUT systemd service unit activity on a Debian 11 (NUT 2.7.4) system with the command:

```bash
root@titan ~ systemctl list-unit-files | grep -i -E "nut|UPS|VENDOR"
```

<table>
<thead>
<tr>
<th>UNIT FILE</th>
<th>STATE</th>
<th>VENDOR</th>
<th>PRESET</th>
</tr>
</thead>
<tbody>
<tr>
<td>nut-driver-enumerator.path</td>
<td>disabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-client.service</td>
<td>alias</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>nut-delayed-ups-shutdown.service</td>
<td>enabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-driver-enumerator.service</td>
<td>disabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-driver.service</td>
<td>static</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><a href="mailto:nut-driver@.service">nut-driver@.service</a></td>
<td>disabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-monitor.service</td>
<td>disabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-py-client-shim.service</td>
<td>enabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-py-monitor.service</td>
<td>enabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-py-server-shim.service</td>
<td>enabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-server.service</td>
<td>enabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>ups-monitor.service</td>
<td>masked</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut-driver.target</td>
<td>disabled</td>
<td>enabled</td>
<td></td>
</tr>
<tr>
<td>nut.target</td>
<td>disabled</td>
<td>enabled</td>
<td></td>
</tr>
</tbody>
</table>

Figure 98: Example of systemd service unit activity for NUT.
Part 3

Appendices

A Starting NUT

This chapter discusses the techniques used to start the NUT software. Each distribution has its own view of how this is to be done, so you should review the systemd service units involved and the scripts that they call.

The NUT software contains several daemons which need to be started to offer the promised NUT service. These daemons are shown in the table in figure 100.

<table>
<thead>
<tr>
<th>Daemon</th>
<th>systemd service unit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>upsdl</td>
<td>nut-server.service</td>
<td>The central daemon which maintains the abstracted view of the UPS units.</td>
</tr>
<tr>
<td>driverv</td>
<td>nut-driver.service</td>
<td>One or more driver daemons as specified in file ups.conf. This service unit is started automatically by systemd whenever upsdl starts. The driver needs more time to get started?, see Manuel Wolfshan’s post in the NUT mailing list.</td>
</tr>
<tr>
<td>upsmoñ</td>
<td>nut-monitor.service</td>
<td>The monitor daemon specifies what is to be done for NOTIFY events.</td>
</tr>
<tr>
<td>upssched</td>
<td>none</td>
<td>For activity such as the heartbeat, the timed action daemon is called by the upssched-cmd script which is specified by the NOTIFYCMD command in upsmoñ.conf.</td>
</tr>
</tbody>
</table>

**TLS Shim daemons defined in Part 2**

upsdTLS.py | nut-py-server-shim.service | The shim daemon placed in front of upsdl 2.7.4 to provide TLS support. |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>upsmoñTLS.py</td>
<td>nut-py-monitor-shim.service</td>
<td>The shim placed in front of upsmoñ 2.7.4 to provide TLS support.</td>
</tr>
</tbody>
</table>

Figure 100: Daemons used by NUT.
Configuration file `nut.conf` specifies which of these daemons the operating system should start, but distributions often ignore the file. The distribution choice is normally correct for a standalone workstation protected by a single UPS, but for more complex situations, you need to review what your distribution does. See chapter 8.1 and `man nut.conf`.

Strictly speaking, this file is not for NUT, but for the process which starts NUT. The initialization process is expected to source this file to know which parts of nut are to be started. Some distributions, e.g. openSUSE, ignore `nut.conf` and start the three NUT layers `driver`, `upsd` and `upsmon`. They assume that `MODE=standalone`. Note that there is no space around the `=` since it is assumed that shell scripts such as Debian’s `/sbin/upsd` source this file.

The possible `MODE` values are:

- **MODE=none**  Indicates that NUT should not get started automatically, possibly because it is not configured or that an Integrated Power Management or some external system, is used to start up the NUT components. If you enable `nut-server.service` Debian\(^{30}\) will display the message:

  \[
  \text{upsd disabled, please adjust the configuration to your needs. Then set MODE to a suitable value in /etc/nut/nut.conf to enable it.}
  \]

  Enabling `nut-monitor.service` will produce a similar message\(^{31}\).

- **MODE=standalone**  This is the most common situation in which line 731 in figure 99 declares that NUT should be started in the “standalone” mode suitable for a local only configuration, with 1 UPS protecting the local system. This implies starting the 3 NUT layers, `driver`, `upsd` and `upsmon` and reading their configuration files.

- **MODE=netserver**  Like the standalone configuration, but may possibly need one or more specific `LISTEN` directive(s) in `upsd.conf`. Since this `MODE` is open to the network, a special care should be applied to security concerns. Debian accepts starting `upsmon` in this mode.

- **MODE=netclient**  When only `upsmon` is required, possibly because there are other hosts that are more closely attached to the UPS, the `MODE` should be set to netclient. If you enable Debian’s systemd service unit `nut-server.service` with this mode, then you will get the same message as for `MODE=none`.

However these alternate modes are merely wishful thinking if your distribution ignores file `nut.conf`. There are other options, see `man nut.conf`.

\(^{30}\)See script `/sbin/upsd`.

\(^{31}\)See script `/sbin/upsmon`.
B  Stopping NUT

B.1 Delayed UPS shutdown with NUT script

We saw in chapter 2, line 45 that the `upsmon.conf` SHUTDOWNCMD directive specifies the command to be used to shut down the system, but what about the UPS which must keep supplying power while the system shuts down? Does the UPS also shut down?, and if so, how?

Chapter 2.5 “The shutdown story for a simple server” explains that somewhere in your distribution, as part of the system shutdown process, there needs to be an action to send a message to the UPS to tell it that some time later, it too will shut down. The notion of “shutdown” for a UPS unit is subtle. What shuts down is usually the supply of power to the power outlets. The UPS unit cuts off the equipment for which it provides battery backup. When this happens you may hear the audible “clunk” of the relays. The unit may also act as a power strip with surge protection, but those outlets are not covered by the protection afforded by the battery.

Note that the UPS does not shutdown at the same time as the system it protects. The UPS shutdown is delayed. By default the delay is 20 seconds. See line 77 if you want to change this.

The delayed UPS shutdown command may be from a shell script or a systemd service unit, but in all cases the key element is the command `upsdrvctl shutdown`.

The NUT project provides a sample script, which is to be placed in a directory of things to be done at the end of the system shutdown. This depends on the distribution.

The Debian 11 distribution places the delayed shutdown script provided by NUT and shown in figure 101 in file `/usr/lib/systemd/system-shutdown/nutshutdown`. The openSUSE distribution does the same.

```bash
#!/bin/sh
/usr/sbin/upsmon -K >/dev/null 2>&1 && /usr/sbin/upsdrvctl shutdown
```

Figure 101: UPS shutdown script `nutshutdown`.

On line 733 the call to `upsmon` with option `-K` checks the POWERDOWNFLAG defined by line 46. The `upsmon` daemon creates this file when running in primary (master) mode whenever the UPS needs to be powered off. See `man upsmon.conf` for details. If the check succeeds, we are free to call `upsdrvctl` to shut down the UPS’s. Note that if you have multiple UPS’s, the command `upsdrvctl shutdown` will shut them all down. If you have say three UPS’s, UPS-1, UPS-2 and UPS-3, and you want to shut down just UPS-2 and UPS-3, then you should specify those UPS’s as shown in line 735. See also `man upsdrvctl`.

```bash
#!/bin/sh
```

Figure 102: UPS shutdown script `nutshutdown` for 2 of 3 UPS’s.
### B.2 Delayed UPS shutdown with a systemd service unit

The script provided by the NUT project in chapter B.1 is executed very late in the shutdown sequence, when it is no longer possible to log the action. If you think that power management is a critical operation and that all critical operations should be logged, then you will need to call for the delayed UPS shutdown earlier in the system shutdown sequence when logging is still possible. This can be done using the systemd service unit shown in figure 103.

```ini
# nut-delayed-ups-shutdown.service
[Unit]
Description=Initiate delayed UPS shutdown
Before=umount.target
DefaultDependencies=no

[Service]
Type=oneshot
ExecStart=/usr/bin/logger -t nut-delayed-ups-shutdown\  "upsdrvctl shutting down UPS"

[Install]
WantedBy=final.target
```

Figure 103: UPS shutdown service unit `nut-delayed-ups-shutdown.service`.

The `ExecStart` directive on line 744 will shutdown all the UPS units managed by this system. The code given is for Debian: other distributions put `upsdrvctl` elsewhere. If you have say three UPS’s, UPS-1, UPS-2 and UPS-3, and you want to shut down just UPS-2 and UPS-3, then instead of line 744 you should specify the required UPS’s as shown in lines 747–748.

```ini
ExecStart=/sbin/upsdrvctl shutdown UPS-2  # Debian
ExecStart=/sbin/upsdrvctl shutdown UPS-3
```

Note that this service unit does not perform the `upsmon -K` test for the `POWERDOWNFLAG`.

The position of this service unit may vary from one distribution to another, see section “unit file load path” in `man systemd.unit(5)`. For example in the openSUSE and Debian distributions, `/etc/systemd/system` is for a user’s scripts, and `/usr/lib/systemd/system-shutdown` is for system scripts. You might use the `/etc/systemd/system` directory if your script is not part of an officially distributed product.

If you install or change this service unit, run command `systemctl --system reenable /etc/systemd/system/nut-delayed-ups-shutdown.service`. Maybe your distribution offers a graphical manager to do this.

For gory details see the systemd documentation. There are over 200 man pages starting with an index. For details of the directories used, see section “unit file load path” in `man systemd.unit`.

[^32]: The `upsdrvctl` program is normally a frontend to the drivers, but in the case of the `shutdown` option `upsdrvctl` does not use the existing driver; it creates a new driver for itself.
C Users and Directories for NUT

NUT normally runs as a non-root user, however the user varies from one distribution to another. Table 104 shows a list of users for a range of distributions. Table 104 also shows the directories used by different distributions for configuration files such as `upsd.conf`.

<table>
<thead>
<tr>
<th>Distribution</th>
<th>ID</th>
<th>User: Group</th>
<th>Directory</th>
<th>ID source</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIX</td>
<td>aix</td>
<td>nut ?</td>
<td>/etc/nut/ ?</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>Amazon</td>
<td>amzn</td>
<td>nut</td>
<td>/etc/ups/ ?</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Arch</td>
<td>arch</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>CentOS</td>
<td>centos</td>
<td>nut</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Apple</td>
<td>darwin</td>
<td>nut</td>
<td>/etc/nut/</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>Debian</td>
<td>debian</td>
<td>nut:nut</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Fedora</td>
<td>fedora</td>
<td>nut</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>FreeBSD</td>
<td>freebsd</td>
<td>uucp</td>
<td>/usr/local/etc/nut/</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>Gentoo</td>
<td>gentoo</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/gentoo-release</td>
</tr>
<tr>
<td>HP-UX</td>
<td>hpux</td>
<td>nut ?</td>
<td>/etc/nut/ ?</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>IPFire</td>
<td>ipfire</td>
<td>nutmon</td>
<td>/etc/nut/</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>Kali</td>
<td>kali</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Mint</td>
<td>linuxmint</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Apple</td>
<td>mac</td>
<td>nut ?</td>
<td>/etc/nut/ ?</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>Mageia</td>
<td>mageia</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Manjaro</td>
<td>manjaro</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>NetBSD</td>
<td>netbsd</td>
<td>nut ?</td>
<td>/etc/nut/ ?</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>Oracle</td>
<td>ol</td>
<td>nut</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>OpenBSD</td>
<td>openbsd</td>
<td>ups (1)</td>
<td>/etc/nut/</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>OpenIndiana</td>
<td>openindiana</td>
<td>nut</td>
<td>/etc/nut/</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>OpenSUSE</td>
<td>opensuse</td>
<td>upsd</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Raspbian</td>
<td>raspbian</td>
<td>nut</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Red Hat</td>
<td>rhel</td>
<td>nut</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Slackware</td>
<td>slackware</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>SUSE</td>
<td>sles</td>
<td>upsd</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>SUSE+SAP</td>
<td>sles_sap</td>
<td>upsd</td>
<td>/etc/ups/</td>
<td>/etc/os-release</td>
</tr>
<tr>
<td>Synology</td>
<td>synology</td>
<td>root ?</td>
<td>/usr/syno/etc/nut/</td>
<td><code>uname -a</code></td>
</tr>
<tr>
<td>Ubuntu</td>
<td>ubuntu</td>
<td>nut</td>
<td>/etc/nut/</td>
<td>/etc/os-release</td>
</tr>
</tbody>
</table>

The editor will be very pleased to hear of errors or omissions in this table.

Figure 104: Users and directories for NUT.
Notes:

1. The OpenBSD user may be \texttt{_ups} which is an OpenBSD convention for identifying unprivileged users. Most OpenBSD add-on software uses unprivileged usernames beginning with an underscore.

2. If NUT is built without specifying the user, then the user is \texttt{nobody:nobody}.

3. FreeNAS identifies itself in \texttt{/etc/os-release} as FreeBSD.

4. The IPFire wiki suggests user \texttt{nutmon} for \texttt{upsmon} but makes no mention of \texttt{upsd}.

5. OpenIndiana: historically, NUT was not included as a package in OpenIndiana, and an OpenIndiana Wiki entry dated 2013 recommended user \texttt{ups} and directory \texttt{/opt/nut/etc/}. The values in the table are taken from OpenIndiana’s current Github data for NUT.
D Using notify-send

The program “wall” used by NUT to put notifications in front of the users is now well past its best-before date and hardly fit for purpose. It has not been internationalized, does not support accented letters or non-latin characters, and is ignored by popular desktop environments such as Xfce, Gnome and KDE. It’s apparent replacement notify-send gives the impression that it has never been tested in any other than the simplest cases, and that it is not ready for industrial strength use. Getting notify-send to work with NUT is not immediately evident, so although notify-send is not a part of NUT, we discuss this problem here.

![Example of a notification.](image)

D.1 What’s wrong with notify-send?

The program notify-send is part of a set of programs which implement the Gnome Desktop Notifications Specification. The introduction says:

≪ This is a draft standard for a desktop notifications service, through which applications can generate passive popups to notify the user in an asynchronous manner of events. ... Example use cases include:

- Scheduled alarm
- Low disk space/battery warnings ... ≫

From this introduction it would seem that desktop notifications are exactly what is needed to present [OL]→[OB] and [OB]→[OB LB] warnings to the users, but unfortunately, things are not that simple.

Program notify-send is a utility which feeds message objects to a message server, such as notifyd. Taking the Xfce desktop environment as an example, Xfce provides its message server called xfce4-notifyd. See man xfce4-notifyd-config, man notify-send and the Desktop Notifications Specification. There is also an xfce4-notifyd web page.

Experience shows that just calling notify-send in the script upssched-cmd does not work. The message simply disappears. Closer examination on the openSUSE distribution with command ps -elf | grep ups shows that daemon upsmon running as user “upsd” calls notify-send to present a message, the notify daemon is launched with the same userid “upsd” as the caller. In Debian, NUT runs as user “nut” and the notify daemon is launched with the name userid “nut”. Users such as “upsd” and “nut” do not have access to the desktop environment.
If the caller is the `upsmon` daemon which has no access to the desktop environment, then neither will the corresponding notification daemon. This is surprising. One would expect a design closer to that of the printer daemon `cupsd` which runs permanently in the background receiving files to be printed. There is only one daemon `cupsd` and that daemon isolates the user from needing to know how to drive printers.

To get the message to show on the user’s screen appears to require two actions:

1. Give user “upsd” (“nut” on Debian) the right to act as any user,
2. Search for logged in users, and for each user construct the user’s environment variable `DISPLAY`, and call utility `notify-send` as that user to notify the user.

## D.2 Give user “nut” (“upsd”) the right to act as any user

To improve security in NUT, the `upsd` and `upsmon` daemons is not executed as root, but rather as a non-root userid. This userid is typically called “nut” or “upsd”. See table 104 for a list of possible users. We will use the name “nut”. “nut” is not a regular user and does not have the access to the X-server needed to display data. This is a problem for the notification service, which we now fix.

Add the following lines to the file `/etc/sudoers`

```bash
# Host alias specification
Host_Alias LAN = 10.218.0/255.255.255.0,127.0.0.1,localhost,gold

nut LAN = (ALL) NOPASSWD:SETENV: /usr/bin/notify-send
```

**Figure 106: Modifications to file `/etc/sudoers`**

Line 750 corresponds to the editor’s system and should be adapted to your setup. On line 752 the directive `SETENV:` is needed for openSUSE but optional for Debian. The file `/etc/sudoers` contains the following warning:

```
This file MUST be edited with the 'visudo' command as root. Failure to use 'visudo'
may result in syntax or file permission errors that prevent sudo from running.
```

See `man sudoers` and `man visudo`. The un-l33t do not have to use vi. Luckily, the command `VISUAL=/usr/bin/emacs visudo -f /etc/sudoers` also does the job.
D.3 Search for and notify logged in users

Figure 107 shows a Bash script `notify-send-all` which can be used in place of `notify-send` to send messages from `upssched-cmd` to all the X display users currently logged in. Script `notify-send-all` accepts as argument the message to be displayed. The message will be displayed indefinitely as “critical”. The editor places the script in file `/usr/local/bin/notify-send-all`.

```bash
#!/bin/bash -u
# notify-send-all sends notifications to all X displays
# Assumes /etc/sudoers allows caller to sudo as any user.
# E.g. nut LAN = (ALL) NOPASSWD:SETENV: /usr/bin/notify-send
# Call with text to be displayed as argument.
XUSERS=$( $(who | grep -E "\([:0-9]*(\.\[0-9]*)*\)" \
  | awk '{print $1$NF}' | sort -u ) )
for XUSER in $XUSERS # E.g. jschmo(:0)
done
```

Figure 107: Bash script `notify-send-all`

Line 758 produces a Bash array of all the users identified by `who` who have X displays. Each item in the array corresponds to a logged in user with an X display and is of the form `jschmo(:0)`.

For each user logged in with an X display, line 761 creates a Bash array containing the user name and the X display number in the form `jschmo :0`.

Line 762 extracts the X display number :0 and on line 763 calls `notify-send` to notify the user as if user “nut” (“upsd” on openSUSE) was that logged in user. Note that environment variable `DISPLAY` is set for that user.

See the discussion “Show a notification across all running X displays” on the stackexchange site.

D.4 Testing the `notify-send-all` setup

A simple way of testing the use of `notify-send` if you are using the chapter 4 configuration is to simply disconnect the wall power for 10 seconds. This is sufficient to provoke `upsmon` into calling `upssched-cmd` which in turn calls `notify-send-all` as shown at line 194.

While wall power is disconnected, use a command such as `ps -elf | grep -E "ups\[dms]\|nut"` to find the programs running as user “nut” (“upsd” on openSUSE):
<table>
<thead>
<tr>
<th>Line</th>
<th>User</th>
<th>PID</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>767</td>
<td>nut</td>
<td>2635</td>
<td>/usr/bin/usbhid-ups -a Eaton</td>
</tr>
<tr>
<td>768</td>
<td>nut</td>
<td>2637</td>
<td>/usr/bin/dummy-ups -a heartbeat</td>
</tr>
<tr>
<td>769</td>
<td>nut</td>
<td>2641</td>
<td>/usr/sbin/upsd</td>
</tr>
<tr>
<td>770</td>
<td>root</td>
<td>2645</td>
<td>/usr/sbin/upsmon</td>
</tr>
<tr>
<td>771</td>
<td>nut</td>
<td>2646</td>
<td>/usr/sbin/upsmon</td>
</tr>
<tr>
<td>772</td>
<td>nut</td>
<td>3217</td>
<td>/usr/sbin/upssched UPS Eaton@localhost: On battery</td>
</tr>
<tr>
<td>773</td>
<td>nut</td>
<td>3236</td>
<td>dbus-launch --autolaunch=d1cd...ca5d2 ...</td>
</tr>
<tr>
<td>774</td>
<td>nut</td>
<td>3237</td>
<td>/bin/dbus-daemon --fork --print-pid 5 ...</td>
</tr>
<tr>
<td>775</td>
<td>nut</td>
<td>3241</td>
<td>/usr/lib/xfce4/notifyd/xfce4-notifyd</td>
</tr>
<tr>
<td>776</td>
<td>nut</td>
<td>3243</td>
<td>/usr/lib/xfce4/xfconf/xfconfd</td>
</tr>
</tbody>
</table>

Lines 767-772 are due to NUT activity, and lines 773-776 are due to the use of `notify-send`. Note on line 775 that the `xfce4-notifyd` daemon is running as user “nut”!

### D.5 References for `notify-send`

1. For a suggestion of how to send notifications on an Apple Mac, see the [posting by Robbie van der Walle](https://mailman.nut-upsuser.org/pipermail/nut-upsuser/2017-June/022132.html) on Sun Jun 11 11:27:55 UTC 2017, in the nut-upsuser mailing list.

2. For a discussion of how to send notifications to all running X-server users, see [Stack Exchange question 2881](https://superuser.com/questions/2881).

3. The Gnome “Desktop Notifications Specification” is still a very long way from being RFC quality.

4. Man pages: See man `xfce4-notifyd-config` and man `notify-send`

5. Xfce4 web page: There is also an `xfce4-notifyd` web page

*These techniques have been tested with the Xfce desktop environment on openSUSE and Debian. The editor would be pleased to hear of any successful adoption of the techniques on Fedora, Arch or Ubuntu based systems, using other desktop environments such as Cinnamon, KDE or Gnome.*
E Log rotation for \texttt{upsdTLS.py} and \texttt{UPSmon.py}

The well known Unix/GNU Linux utility program \texttt{logrotate} provides a convenient way of managing log files. See \texttt{man logrotate(8)} NUT 2.7.4 already provides a declaration for it’s log files. The following declaration provides separate management for the log files created by \texttt{upsdTLS.py} and \texttt{UPSmon.py}.

The file should be created as \texttt{/etc/logrotate.d/NUT} with ownership \texttt{root:root} and permissions 644.

```plaintext
# Log rotation configuration for upsdTLS.py, UPSmon.py
# Rotate NUT log file either monthly or when exceeding 5 Mb
# For more information, refer to logrotate(8) manual page:
# http://linuxcommand.org/man_pages/logrotate8.html
/var/log/NUT.log {
  missingok
  notifempty
  size=5M
  rotate 12
  monthly
  create 0600 nut nut
}
```

Figure 108: Log rotation for \texttt{upsdTLS.py} and \texttt{UPSmon.py}

Line 788 calls for a log rotation every month, and line 787 requires keeping 12 previous months’ logs, so in all there will be one year’s records.

Line 789 creates a file with owner \texttt{nut:nut} suitable for Debian. You should adapt this for your distribution. See table 104.
Part 4

UPS monitoring using Python3 script

*Warning: This is Work in Progress*

Part 1 of this documentation discussed the way in which UPS activity reported by `upsd` can be monitored using the monitoring software provided with NUT 2.8.0. This part 4 covers the use of Python3 scripts and OpenSSL/TLS to monitor the same UPS activity.

This Part provides descriptions of Python3 scripts `UPSmon.py` and `mkUPSmonconf.py`. The script `UPSmon.py` requires a helper script to create TLS certificates. The script `mkNUTcert.py` is described in part 2 chapter 10.

The scripts and their SHA1 check sums may be downloaded from [http://rogerprice.org/NUT](http://rogerprice.org/NUT)

**F** Python3 script **`UPSmon.py`** version 1.2

![Diagram](UPSmon.svg)

Figure 109: `UPSmon.py` requires TLS.

**F.1 What is **`UPSmon.py`**?**

`UPSmon.py` is a Python3 script which replaces `upsmon`, `upssched` and `upssched-cmd`. The configuration files `upsmon.conf` and `upssched.conf` are replaced by a single configuration file `UPSmon.conf`. The current version 1.2 of `UPSmon.py` is “experimental”, intended for experiment and demonstration.
F.1.1 Principal differences between `upsmon` and `UPSmon.py`

The principal differences between NUT’s `upsmon` and `UPSmon.py` are:

1. **`UPSmon.py`** is written in [Python3](https://www.python.org) rather than K&R C. It is hoped that this use of a well-known higher level language will encourage further experimentation. The script is in one single file rather than the many separate files used in NUT C code. Like the NUT C code, the script is not object oriented. To assist further development, the script provides 116 error and warning messages, and the `-D` and `-Y` debug options provide a detailed “walk-through” of the script’s operations.

2. Unlike `upsmon`, `UPSmon.py` does not retain the parent process when forking to a non-privileged user. This improves security, but implies that the non-privileged user such as `nut` has `sudo` rights for programs `wall`, `notify-send` and `shutdown`.

3. `UPSmon.py` assumes that it will be managing a large number of physical and virtual UPS and other power supply units. The management may be of the type “primary” or “secondary”, known formerly as “master” or “slave”, or simply as an observer with the primary/secondary shutdown decisions taken elsewhere.

4. The UPS units, real and virtual, are collected into groups. Every UPS must be in exactly one group. `upsmon` does not support groups.

5. All UPS’s must be individually identified. Unlike NUT, there are no “wildcard” UPS’s. Each UPS has a formal “fully qualified” name which is of the form `group:ups@host:port`, for example `HB:heartbeat@bigbox:3493`, although shortened forms are used where there is no ambiguity.

6. The configuration file `UPSmon.conf` is read by PLY; Python Lex and Yacc. This implies a slightly slower start-up than NUT but allows freer formats and many possibilities for future expansion.

7. The `upsmon.conf` declarations `DEADTIME`, `FINALDELAY`, `HOSTSYNC`, `NOCOMMWARNTIME` and `RBWARNTIME` are not needed in `UPSmon.conf` since they are timers which can be expressed directly if needed.

8. All communication between `UPSmon.py` and `upsd` is TLS encrypted. The version of OpenSSL used is too recent to be compatible with nut 2.7.4, so a shim front end for `upsd` called `upsdTLS.py` is provided to accept TLS encrypted commands from `UPSmon.py` and then relay that traffic to the local `upsd`. Part 2 describes `upsdTLS.py`. The options chosen for TLS call for the latest version with full checking of the certificates. Use of the earlier and now deprecated SSL is excluded.

9. `UPSmon.py` supports two loggers: the system log and a text based NUT-specific log.

10. `UPSmon.py` does not require a supplementary program such as `upssched` or a script such as `upssched-cmd`. The functions of those programs are available in `UPSmon.py`. NUT’s `upsmon`
<table>
<thead>
<tr>
<th>Action</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>STARTTIMER name value</td>
<td>Start timer with the given name and value in seconds.</td>
</tr>
<tr>
<td>CANCELTIMER name</td>
<td>Cancel timer with the given name.</td>
</tr>
<tr>
<td>EMAIL FROM text TO text SUBJECT text MESSAGE text</td>
<td>Send email.</td>
</tr>
<tr>
<td>WALL text</td>
<td>Send text to local wall.</td>
</tr>
<tr>
<td>NOTIFY text</td>
<td>Place text on screens of all logged-in local accounts.</td>
</tr>
<tr>
<td>PRINT text</td>
<td>Send text to STDOUT.</td>
</tr>
<tr>
<td>EPRINT text</td>
<td>Send text to STDERR.</td>
</tr>
<tr>
<td>NUTLOG text</td>
<td>Send text to NUT-specific logger.</td>
</tr>
<tr>
<td>SYSLOG text</td>
<td>Send text to system logger.</td>
</tr>
<tr>
<td>SETFSD name</td>
<td>Send FSD to upsd for UPS name.</td>
</tr>
<tr>
<td>SHUTDOWN option when</td>
<td>Shutdown the system, e.g. with /usr/sbin/shutdown -h now.</td>
</tr>
<tr>
<td>DEBUG level</td>
<td>Turn on/off the debugging output to the NUT log.</td>
</tr>
</tbody>
</table>

Figure 110: Actions provided by UPSmon.py.

provides three NOTIFYFLAG options: SYSLOG, WALL and EXEC. UPSmon.py replaces these with the more complete set of actions shown in figure 110.

11. Texts to be included in messages may be given names, and may incorporate other named messages. The upsmon NOTIFYMSG % substitution is extended to provide the substitutions shown in table 111.

| %%(u)s | Fully qualified name of the UPS unit |
| %%(c)s | Current charge of the UPS unit |
| %%(e)s | The event which has produced this message |
| %%(b)s | A banner of the form “2020-08-15 upsd@bigbox” |
| %%(h)s | The hostname, the name of the local machine |

Figure 111: % substitutions available in messages.

12. The low battery status [LB] provided by upsd is supplemented by three further low battery statuses [LB1], [LB2] and [LB3] for which the trip levels may be set in UPSmon.conf.

13. When the sum of the POWERVALUE in a group with status [OL] does not meet the group’s MINSUPPLIES requirement, UPSmon.py raises status [LS]. In upsmon this is implicit in the client’s logic.
F.2 Compatibility with `upsmon`.

`UPSmon.py` can be run at the same time and in the same machine as `upsmon`. `UPSmon.py` does not interfere with direct access to `upsd` port 3493. Command line utility programs such as `upsc` still function normally.

F.3 Overview of `UPSmon.py`

The script has a configuration file, and many options. In general few options and in some simple cases none at all need be changed. To see the options and their default values you can enter command `UPSmon.py --help`

```
791 $ UPSmon.py --help
792 usage: UPSmon.py [-h] [--command fsd|reload|stop] [--config <file>]
794       [-PIDfile <file>] [-shell <executable>] [-sudo <executable>]
795       [-testSHUTDOWNflag] [-upsdtimeout <float>] [-user <user>]
796       [-version] [-wall <executable>]
```

Figure 112: Command `UPSmon.py --help`

Let’s look at these optional arguments in more detail.

-h, --help Show this help message and exit.

--command fsd|reload|stop Send command to `UPSmon.py` process and exit. Valid commands are fsd, reload, stop.

-c <file>, --config <file> The configuration file. `UPSmon.py` tries to guess where you put this. Debian sysadmins might see `/etc/nut/UPSmon.conf`. OpenSUSE admins might see `/etc/ups/...` See table 104 for a list of possible directories.

-D, --debug Increase the debugging level, may be repeated but then you get more than any human can read. Debugging output is written into a NUT log file. This option does not cover Lex and Yacc.

-Y, --debugYacc Increase the debugging level for Lex and Yacc. No human being should ever be required to read this stuff. Debugging output is written into a NUT log file.

-l <file>, --logfile <file> The log file, with default `/var/log/NUT.log`. Progress and error messages and the stuff generated by options -D and -Y go into this file. Note that if `upsdTLS.py` and `UPSmon.py` are running in the same machine they will write into the same log. See chapter E for an extension to `logrotate` to cover this file.
-n <executable>, --notify <executable> The notification executable. The default is /usr/bin/notify-send -t 0 -u critical

--PIDfile <file> The child PID is written into this file, for the greater pleasure of systemd. The default is /run/nut/UPSmon.pid Do not change this unless you know what you are doing. You should also review the systemd service unit.

--shell <file> The shell that will process the SHELLCMD actions. The default is /bin/bash -c

--sudo <executable> Authorise user to execute code as another user. The default is /usr/bin/sudo. Use of sudo assumes that file /etc/sudoers allows the caller to sudo as the required user. For example

```
nut LAN = (ALL) NOPASSWD:SETENV: /usr/bin/notify-send, /usr/bin/wall
nut LAN = (ALL) NOPASSWD:SETENV: /usr/sbin/shutdown
```

where LAN is defined by a declaration such as

```
Host_Alias LAN = 10.218.0/255.255.255.0, 127.0.0.1, localhost
```

To update /etc/sudoers, use visudo, for example VISUAL=/usr/bin/emacs visudo -f /etc/sudoers.

-<executable>, --testSHUTDOWNflag Test the SHUTDOWN flag. Not implemented.

--upsdtimeout <float> Socket timeout for exchanges with upsdl. The default is 5.0 seconds.

-u <user>, --user <user> After launch as root, run as this user. UPSmon.py tries to guess the user. OpenSUSE admins would probably see upsdl, whereas Debian admins would see nut. See table \ref{upsdl-users} for a list of possible users.

-v, --version Show program, Python and SSL/TLS versions, then exit.

-w <executable>, --wall <executable> The wall executable. The default is /usr/bin/wall
F.4 Running **UPSmon.py**

It is possible, in a simple installation, to run the daemon **UPSmon.py** in the same machine as **upsd**. However the design is for remote monitoring of one or more **upsd** servers across a hostile network. **UPSmon.py** assumes that the server(s) is/are already running and ready to receive the **STARTTLS** command.

If you use systemd to manage your box, then you will need to create a new service unit, since systemd is unable to start two forking services from the same unit. See [man systemd.service(5)](man). There can only be one **Type=forking** per unit.

Copy the file `/usr/lib/systemd/system/nut-monitor.service` to `/etc/systemd/system/nut-py-monitor.service` and modify the new file shown in figure 113. Lines 799, 801 and 802 have been changed.

```ini
[Unit]
Description=Network UPS Tools - Python - power device monitor
After=local-fs.target network.target

[Service]
ExecStart=/usr/sbin/UPSmon.py
PIDfile=/run/nut/UPSmon.pid
Type=forking

[Install]
WantedBy=multi-user.target
```

Figure 113: systemd service unit **nut-py-monitor.service** for **UPSmon.py**.

You may choose to place the **UPSmon.py** script in directory `~/usr/sbin/` or make `~/usr/sbin/UPSmon.py` a link to wherever you put the Python script. Note that systemd service units in `/etc/` take precedence over those in `/usr/lib/`. See [man systemd.unit(5)](man). After you have made the changes, you should run the command `systemctl daemon-reload`. See [man systemctl(1)](man). Before running **upsdTLS.py** the first time, you will need to run the command

```bash
systemctl enable nut-py-monitor.service
```

The following `systemctl` commands will be of use to you:

- `systemctl daemon-reload` to make any changes to the service unit available to systemd.
- `systemctl enable nut-py-monitor.service` to make the daemon **UPSmon.py** operational and “startable”.
- `systemctl start nut-py-monitor.service` to start **UPSmon.py**. Note that this will not erase the log file. If you want to clear the log file then you need to do that yourself. See also chapter E for a discussion of log rotation.
systemct1 status nut-py-monitor.service to see the current status of daemon UPSmon.py.

systemct1 stop nut-py-monitor.service to stop UPSmon.py.

UPSmon.py should start automatically when the system starts, but it can also be stopped and started manually with the systemctl commands.

Serious errors will prevent UPSmon.py from starting and you can read about them in the NUT log and in the system log. After starting UPSmon.py, check the NUT log for warnings and other error messages. Look for the reports beginning “Sanity checks for this configuration ...”.
### F.5 UPSmon.py’s events based un upsd’s status changes

<table>
<thead>
<tr>
<th>Status change symbol</th>
<th>Event based on Status Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>None-&gt;ALARM</td>
<td>ALARM-&gt;None</td>
</tr>
<tr>
<td>None-&gt;BOOST</td>
<td>BOOST-&gt;None</td>
</tr>
<tr>
<td>None-&gt;BYPASS</td>
<td>BYPASS-&gt;None</td>
</tr>
<tr>
<td>None-&gt;CAL</td>
<td>CAL-&gt;None</td>
</tr>
<tr>
<td>None-&gt;CHRG</td>
<td>CHRG-&gt;None</td>
</tr>
<tr>
<td>None-&gt;DISCHRG</td>
<td>DISCHRG-&gt;None</td>
</tr>
<tr>
<td>None-&gt;LB</td>
<td>LB-&gt;None</td>
</tr>
<tr>
<td>None-&gt;OFF</td>
<td>OFF-&gt;None</td>
</tr>
<tr>
<td>OL-&gt;OB</td>
<td>OB-&gt;OL</td>
</tr>
<tr>
<td>None-&gt;OVER</td>
<td>OVER-&gt;None</td>
</tr>
<tr>
<td>None-&gt;RB</td>
<td>RB-&gt;None</td>
</tr>
<tr>
<td>None-&gt;TEST</td>
<td>TEST-&gt;None</td>
</tr>
<tr>
<td>None-&gt;TRIM</td>
<td>TRIM-&gt;None</td>
</tr>
</tbody>
</table>

**Figure 114:** Symbols used to represent events monitored by UPSmon.py.

**UPSmon.py**, like NUT’s upsmon is an example of a client of upsd\(^{33}\). Just as upsmon does, it runs permanently as a daemon in a local or remote box, polling the status changes of the UPS unit. It is able to react to changes in the UPS state for example by emitting warning messages, or shutting down the box. The actions are specified in the configuration file `UPSMon.conf` which will be discussed in specific examples.

As the state of a UPS evolves, each status change, called an “EVENT”, is identified with the symbols shown in figure 114 (These correspond to the NOTIFY events, also known as a “notifytype” in NUT.)

For example, figure 109 shows what happens when wall power fails. Daemon upsd has polled the UPS, and has discovered that the UPS is supplying power from it’s battery. The `ups.status` changes to [OB]. Daemon UPSmon.py has polled upsd, has discovered the status change and has generated the `OL->OB` event.

\(^{33}\)See chapter 1.3 for details of upsd.
F.5.1 **UPSmon.py**’s additional status symbols and events

<table>
<thead>
<tr>
<th>Other statuses generated by UPSmon.py</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COMM</strong></td>
</tr>
<tr>
<td><strong>NOCOMM</strong></td>
</tr>
<tr>
<td><strong>FSD</strong></td>
</tr>
<tr>
<td><strong>LB1</strong></td>
</tr>
<tr>
<td><strong>LB2</strong></td>
</tr>
<tr>
<td><strong>LB3</strong></td>
</tr>
<tr>
<td><strong>LS</strong></td>
</tr>
<tr>
<td><strong>TICK</strong></td>
</tr>
<tr>
<td><strong>TOCK</strong></td>
</tr>
<tr>
<td><strong>TO</strong></td>
</tr>
</tbody>
</table>

Figure 115: Additional status symbols generated by UPSmon.py.

<table>
<thead>
<tr>
<th>Status change symbol</th>
<th>Other Events generated by UPSmon.py</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM-&gt;NOCOMM</td>
<td>NOCOMM-&gt;COMM</td>
</tr>
<tr>
<td>Communication with the UPS in now lost/restored.</td>
<td></td>
</tr>
<tr>
<td>None-&gt;FSD</td>
<td>FSD-&gt;None</td>
</tr>
<tr>
<td>The UPS is/is not now in Forced ShutDown mode.</td>
<td></td>
</tr>
<tr>
<td>None-&gt;LB1</td>
<td>LB1-&gt;None</td>
</tr>
<tr>
<td>The UPS battery charge is now low/no longer low with respect to critical level 1.</td>
<td></td>
</tr>
<tr>
<td>None-&gt;LB2</td>
<td>LB2-&gt;None</td>
</tr>
<tr>
<td>The UPS battery charge is now low/no longer low with respect to critical level 2.</td>
<td></td>
</tr>
<tr>
<td>None-&gt;LB3</td>
<td>LB3-&gt;None</td>
</tr>
<tr>
<td>The UPS battery charge is now low/no longer low with respect to critical level 3.</td>
<td></td>
</tr>
<tr>
<td>None-&gt;LS</td>
<td>LS-&gt;None</td>
</tr>
<tr>
<td>Within a group, the total power value of the UPS units with status [OL] does/does not satisfy the MIN-SUPPLIES declaration.</td>
<td></td>
</tr>
<tr>
<td>None-&gt;TICK</td>
<td>TICK-&gt;None</td>
</tr>
<tr>
<td>A heartbeat UPS has/has not generated a [TICK].</td>
<td></td>
</tr>
<tr>
<td>None-&gt;TOCK</td>
<td>TOCK-&gt;None</td>
</tr>
<tr>
<td>A heartbeat UPS has/has not generated a [TOCK].</td>
<td></td>
</tr>
<tr>
<td>TO-&gt;my-timer</td>
<td>Timer “my-timer” has completed.</td>
</tr>
</tbody>
</table>

Figure 116: Additional events monitored by UPSmon.py.
In addition to the events based on *upsd* status changes, **UPSmon.py** also generates further statuses and status changes based on its monitoring of *upsd*. See figure 115. Changes in these additional statuses give rise to additional events shown in figure 116.

### F.6 Configuration file

There is just one configuration file for **UPSmon.py** which replaces **upsmon.conf**, **upssched.conf** and **upssched-cmd**. The formal grammar for this configuration file is in chapter H. The file contains:

1. Comments and blank lines. A comment begins with a # character found outside a quoted text, and continues up the end-of-line.
2. Initial declarations. See section F.6.1
3. One or more group declarations. See section F.6.2.

The following technical terms are used in the descriptions of the configuration file:

**quotation mark** One of the following five styles of text marker. See chapter G for help in typing the characters which may not be on your keyboard.

1. double quotation marks: "*bla...bla...*" which are probably on your keyboard,
2. single quotation marks: ' *bla...bla...*' which are also on your keyboard,
3. french guillemets: «*bla...bla...»,
4. mathematical left ceiling/right floor [ *bla...bla...* ] and
5. corner brackets used for quotations in asian languages: ⌈*bla...bla...⌉.

**quotetext** A text in quotation marks. E.g. «Hello World»

**quotetexts** A sequence of one or more quotetext declarations. E.g. «Today is » «Friday.» This results in a single text “Today is Friday.”

**number** An integer or floating point number such as 15 or 2.8.

**name** Names for groups, timers, UPS’s, messages. The name begins with [a-zA-Z_] and continues with as many of [a-zA-Z0-9_%+-_] as you like. E.g. UPS31.a-BIG_BOX.

**ups-name** All UPS’s must be individually identified. Unlike NUT, there are no “wildcard” UPS’s. Each UPS has a formal “fully qualified” name which is of the form *group:* *ups@host:* *port* for example HB:heartbeat@bigbox:3493, although shortened forms are used where there is no ambiguity.

---

34 I couldn’t decide which ones to use so I kept them all. Ed.
F.6.1 Initial declarations

The initial declarations are

**SMTPSERVER quotetext PORT number USER quotetext PASSWORD quotetext**  
If you want to send e-mails, you must provide details of your e-mail service provider. For example `SMTPSERVER ‘mail.gandi.net’ PORT 465 USER ‘mbox@example.com’ PASSWORD ‘1234’`. Connections with the SMTP server are always TLS encrypted.

**LET name = quotetexts**  
Provide a name for one or more `quotetext`. This saves a lot a typing. For example `LET banner = [%(b)s] UPS=%(u)s charge=%(c)s event=%(e)s]`. The named message `LET hostname = hostname` is built in. There may be multiple LET declarations, and each may make use of names declared in previous LETs.

**MAXNOTIFY number**  
This limits the number of on-screen notifications, and was needed during early debugging when things often exploded. It will probably be removed in the future. The default is 20.

** POLLFREQ number**  
This is the polling period for all UPS units managed by this `UPSmon.py` instance. The default, which is the recommended value, is 5 seconds. See also `man upsmon.conf`

**POLLFREQALERT number**  
This is the polling period for all UPS units managed by this `UPSmon.py` instance when any one of them is in status [OB]. The default is 5 seconds.

F.6.2 Group declarations

Each group in a sequence of groups begins with a `GROUP` declaration header followed by other declarations described in this section.

Within a group, a **condition** is either empty or has the form `IF old-status -> new-status`. The condition has the value True if in the sequence of events from the given UPS, that UPS now has status `new-status`. For example the expression `IF OB -> OL` is True if the UPS currently has status [OL] and False if the UPS has status [OB]. Note that `old-status -> new-status` must be a valid event as listed in chapter F.5.

The `GROUP` declaration header is as follows:

**GROUP name HOST name PORT number CERTFILE name/quotetext**  
One or more UPS units share the same HOST, PORT and TLS CERTFILE. E.g. `GROUP LOCAL HOST localhost PORT 401 CERTFILE /etc/nut/gold-client.cert.pem`. The UPS units attached to this host are grouped together and each is specified by a `MONITOR` declaration in this group.

Within each group the following declarations may appear:
LET name = quotetexts    Further named texts. Note that there is only one name space shared by all LET declarations. It’s up to you to avoid clashes.

The name battery.charge.low. for \( i = 1..3 \) is a special case in which the quotetexts must be quoted integer. The effect is to assign the integer value as the battery charge level at which the events None->LB\( i \) and LB\( i \)->None will occur. For example LET battery.charge.low.2 = '33' The level is set for the most recently defined UPS, i.e. the previous MONITOR declaration. The default levels are LB1=50, LB2=25 and LB3=12.

MONITOR ups-name POWERVAL number UPSDUSER name PASSWORD quotetext TYPE name
Each UPS unit to be managed must be declared. The \textit{ups-name} must match the name in the ups.conf declaration. See for example line \[32\]. The POWERVAL is the number of power supplies that this UPS feeds. The \textit{UPSDUSER} is the “user” declared in ups.d.users. See line \[40\]. The PASSWORD is the value declared in ups.d.users. See line \[41\]. The \textit{TYPE} value must be \texttt{primary} or \texttt{secondary}. The earlier values \texttt{master}, \texttt{slave} are accepted. In NUT’s upsmon.conf \texttt{primary} means this system will shutdown last, allowing any secondaries time to shutdown first. The declaration is included here to facilitate interworking with upsmon but in UPSmon.py, it is merely a declaration of intention, since the logic is decided by the declared actions.

E.g. MONITOR ups1 POWERVAL 1 UPSDUSER leboss PASSWORD 'sekret' TYPE primary

MINSUPPLIES number
Declare for each GROUP the number of power supplies which must be operational, and that if fewer are available, NUT must shut down the server. The default value is 1 if this declaration is omitted. See chapter \[3.2\]

More work needed here to create a MINSUPPLIES event.

WHEN ups-name REPORTS old-status->new-status : actions
Declare what, if anything, is to be done when an event, i.e. a status change occurs. The \textit{ups-name} may be abbreviated when there is no ambiguity, but the fully qualified UPS name is always used internally.

The sequence old-status->new-status defines a status change, i.e. an event. The valid events are listed in chapter \[F.5\].

When the event specified for this UPS is detected, the \textit{actions} will be executed. For example WHEN ups1 REPORTS None->LB : \textbf{actions} Let’s hope those actions do something useful.

WHEN ups-name TIMEOUT timer-name : actions
Declare what, if anything, is to be done when a timeout occurs. The \textit{timer-name} will have been declared by a previous \texttt{STARTTIMER} action. \texttt{TIMEOUT} may be written as \texttt{TO}. For example

WHEN ups1 TO final-delay : \texttt{SHUTDOWNCMD /sbin/shutdown -h now}
**condition** CANCEL_TIMER  *timer-name*  

The *timer-name* must have been declared by a previously executed **START_TIMER** action. It is not an error to cancel a timer after it has run out.

**condition** DEBUG 0/1/2  

Initiate or terminate debugging output. Note that since a set of actions is executed in random order, you should not rely on a **DEBUG** in the same set of actions as the action you wish to trace.

**condition** EMAIL FROM *quotetext*  

**TO *quotetext*  

**SUBJECT *quotetext*  

**MESSAGE *quotetext*  

Send an email via the mail server declared in the introduction by **SMTP_SERVER**. E.g.

```
EMAIL FROM <UPSmon.py@example.com>
**TO <sysadmin@bigbox.com>
**SUBJECT <Msg-1-min>
**MESSAGE <Msg-1-min>
```

Where *Msg-1-min* has been previously declared in a **LET**. Note that the message must be in 7-bit ascii. Any character more exotic will be converted to a "\~".

**condition** START_TIMER  *timer-name*  *number*

Declare and start a timer with the given name, and the given value in seconds. It is up to you to avoid name conflicts between timers and with other names. E.g. **START_TIMER** final-delay 5

**condition** EPRINT *quotetext*  

Send the *quotetext* to STDERR. When UPSmon is daemonized, **EPRINT** is ignored. Use **NUTLOG** instead.

**condition** NOTIFY *quotetext*  

Place the *quotetext* in an on-screen notification for all logged-in users. If **UPSmon.py** is run as a non-privileged user, which is usually the case, than that user, for example **nut**, must be given access to program **notify-send** in file **/etc/sudoers**. See chapter D.2 for details of how to do this. See also **man sudo(8)** for lots and lots of brain-damaging detail.

**condition** NUTLOG *quotetext*  

Write the *quotetext* into the NUT log file specified by option **--logfile**. The *quotetext* will be prepended with a timestamp and a reminder of the source program and line number. For example action **NUTLOG** «Hello World» might add the following line to the log file:

```
18:32:25 UPSmon.py[3498] Hello World
```

See chapter E for an extension to **logrotate** to cover this file.

**condition** PRINT *quotetext*  

Send the *quotetext* to STDOUT. When UPSmon is daemonized, **PRINT** is ignored. Use **NUTLOG** instead.

---

[35] "Previous" means previous in time, not in the order of declarations in **UPSmon.conf**.
condition SETFSD ups-name

This action sets the “forced shutdown” flag on each secondary (slave) UPS when the primary (master) plans to power it off. This is done so that secondary (slave) systems will know about the power loss and shut down before the UPS power disappears. UPSmon.py, like upsmon, in primary (master) mode is the primary user of this function.

Setting this flag makes [FSD] appear for this UPS. This [FSD] should be treated just like a [OB LB]. To use this action, you need upsmon primary in upsd.users, or “FSD” action granted in upsd.users. See man upsd.users.

Note that [FSD] in upsd is currently a latch - once set, there is no way to clear it short of restarting upsd. This may cause issues when upsd is running on a system that is not shut down due to the UPS event.

See the Network UPS Tools Developer Guide, Network protocol information

condition SHELLCMD quotetexts

Call on the shell defined by the option --shell to execute the command given by the quotetexts. For example

SHELLCMD <<"Today is $(date)" >> /var/log/NUT.log

might write “Today is Tue Oct 13 10:09:02 CEST 2020” into the log file.

condition SHUTDOWNCMD quotetexts

Call for a system shutdown using the command specified by the quotetexts. For example, SHUTDOWNCMD " /sbin/shutdown -h 0". If UPSmon.py is run as a non-privileged user, which is usually the case, than that user, for example nut, must be given access to program shutdown in file /etc/sudoers. See chapter D.2 for details of how to do this. See also man sudo(8) for lots of detail.

condition SYSLOG quotetexts

Write the quotetexts into the system log. The system log provides 8 levels of urgency. They are shown, in order of decreasing importance, in table 117. If your quotetexts are prefixed with one of these urgency indicators, your mes-

<table>
<thead>
<tr>
<th>urgency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[emerg]</td>
<td>System is unusable</td>
</tr>
<tr>
<td>[alert]</td>
<td>Action must be taken immediately</td>
</tr>
<tr>
<td>[crit]</td>
<td>Critical conditions</td>
</tr>
<tr>
<td>[err]</td>
<td>Error conditions</td>
</tr>
<tr>
<td>[warning]</td>
<td>Warning conditions</td>
</tr>
<tr>
<td>[notice]</td>
<td>Normal, but significant, condition</td>
</tr>
<tr>
<td>[info]</td>
<td>Informational message (default)</td>
</tr>
<tr>
<td>[debug]</td>
<td>Debug-level message</td>
</tr>
</tbody>
</table>

Figure 117: System log urgency levels.

sage will be logged at the required level e.g. SYSLOG [[debug]] UPS %(u)s burning]]. The default level is [info].
**condition WALL quotetexts**  
Place the *quotetexts* in a console message for all logged-in users. If **UPSmon.py** is run as a non-privileged user, which is usually the case, than that user, for example *nut*, must be given access to program *wall* in file `/etc/sudoers`. See chapter D.2 for details of how to do this. See also `man sudo(8)` for details. Note that *wall* does not support UTF-8.

## G Typing alternative text bracketing characters

Text in **UPSmon.conf** must be in brackets. You are free to choose which style; the following table may help you to type styles which are not on your keyboard.

<table>
<thead>
<tr>
<th>Unicode</th>
<th>Emacs</th>
<th>Vim</th>
<th>Full name</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;</td>
<td>U+0022</td>
<td>Keyboard &quot;</td>
<td>QUOTATION MARK (Used left and right)</td>
</tr>
<tr>
<td>’</td>
<td>U+0027</td>
<td>Keyboard ’</td>
<td>APOSTROPHE (Used left and right)</td>
</tr>
<tr>
<td>«</td>
<td>U+00AB</td>
<td>AltGr{ or</td>
<td>LEFT-POINTING DOUBLE ANGLE QUOTATION MARK</td>
</tr>
<tr>
<td></td>
<td>Ctrl-q 00ab</td>
<td>Ctrl-v u00ab</td>
<td></td>
</tr>
<tr>
<td>»</td>
<td>U+00BB</td>
<td>AltGr} or</td>
<td>RIGHT-POINTING DOUBLE ANGLE QUOTATION MARK</td>
</tr>
<tr>
<td></td>
<td>Ctrl-q 00bb</td>
<td>Ctrl-v u00bb</td>
<td></td>
</tr>
<tr>
<td>⌈</td>
<td>U+23A1</td>
<td>Ctrl-q 23a1</td>
<td>LEFT SQUARE BRACKET UPPER CORNER</td>
</tr>
<tr>
<td>⌊</td>
<td>U+23A6</td>
<td>Ctrl-q 23a6</td>
<td>RIGHT SQUARE BRACKET LOWER CORNER</td>
</tr>
<tr>
<td>⌈</td>
<td>U+2E22</td>
<td>Ctrl-q 2e22</td>
<td>TOP LEFT HALF BRACKET</td>
</tr>
<tr>
<td>⌊</td>
<td>U+2E25</td>
<td>Ctrl-q 2e25</td>
<td>BOTTOM RIGHT HALF BRACKET</td>
</tr>
</tbody>
</table>

Figure 118: Alternative text bracketing characters.
H Grammar for **UPSmon.conf**

The **UPSmon.conf** file is parsed using David Beazley’s PLY\(^{36}\) This is a pure Python approach to Lex and Yacc. There are no separate Lex and Yacc files. For background reading see “*lex & yacc*” by John R. Irvine, Tony Mason and Doug Brown, O’Reilly, first published 1990, ISBN: 1-56592-000-7.

The PLY’s Lex and Yacc produce an abstract syntax tree known as **AST**. This is then interpreted as instructions to create a new configuration. If there are no errors, the new configuration is passed to **UPSmon.py**, otherwise **UPSmon.py** continues with the previous configuration. You can see **AST** in the log file if you run **UPSmon.py** with option `-D`.

H.1 Lexical structure

The configuration file is assumed to be encoded in UTF-8, and contains comments, tokens (keywords and symbols), numbers and quoted text interspersed with white space.

**Whitespace** Whitespace is any combination of the characters space, tab and newline. Whitespace serves only to separate the other components of a configuration file.

**Comments** The character `#` outside a quoted text begins a comment which continues up to the end of the line. The comment is ignored by the parser. A `#` inside a quoted text does not begin a comment. This is the same comment style as **upsmon.conf** and many other configuration files.

**Names** Names are labels which identify UPS units, timers, named messages, ... They are not quoted and are made up of the 67 characters `a-zA-Z0-9._%+-`. The leading character must be one of the 53 characters `a-zA-z_`.

**Numbers** Numbers are non-negative and may be floating point. They are not quoted. E.g. `5.5`.

**Tokens** The tokens are names given to every piece of input that is recognisable by the lexer. They are shown in figure 120 The tokens are presented in the order in which they are tested by the lexer.

**Quoted text** Text is always quoted. The possible quotation marks are shown in figure 118 E.g. `"text"`, `'text'`, `<text>`, `[text]` and `«text»`. A quoted text may not contain a newline or it’s terminating quote character. E.g. `<text>` is an error as is `<text>.

**Statuses** The lexer recognises the following UPS statuses: **None ALARM BOOST BYPASS CAL CHRG DEAD DISCHRG FSD LB COMM OB OFF OL OVER RB TEST TICK TOCK TRIM**

**Events** An event is a transition from one status to another, and is seen by the lexer as **STATUS RARR STATUS**, e.g. **None→LB**.

---

\(^{36}\) See David Beazley’s PLC (Python Lex-Yacc) page at [https://www.dabeaz.com/ply/](https://www.dabeaz.com/ply/)
<table>
<thead>
<tr>
<th>Token</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>APCUPSDUSER</td>
<td>Keyword</td>
</tr>
<tr>
<td>CANCELTIMER</td>
<td>Keyword</td>
</tr>
<tr>
<td>CERTFILE</td>
<td>Keyword</td>
</tr>
<tr>
<td>COLON</td>
<td>Symbol :</td>
</tr>
<tr>
<td>DEBUG</td>
<td>Keyword</td>
</tr>
<tr>
<td>EMAIL</td>
<td>Keyword</td>
</tr>
<tr>
<td>EPRINT</td>
<td>Keyword</td>
</tr>
<tr>
<td>EQ</td>
<td>Symbol =</td>
</tr>
<tr>
<td>FROM</td>
<td>Keyword</td>
</tr>
<tr>
<td>GROUP</td>
<td>Keyword</td>
</tr>
<tr>
<td>HOST</td>
<td>Keyword</td>
</tr>
<tr>
<td>IF</td>
<td>Keyword</td>
</tr>
<tr>
<td>LET</td>
<td>Keyword</td>
</tr>
<tr>
<td>MAXNOTIFY</td>
<td>Keyword</td>
</tr>
<tr>
<td>MESSAGE</td>
<td>Keyword</td>
</tr>
<tr>
<td>MINSUPPLIES</td>
<td>Keyword</td>
</tr>
<tr>
<td>MONITOR</td>
<td>Keyword</td>
</tr>
<tr>
<td>NAME</td>
<td>Start with a-zA-z_ then a-zA-Z0-9_.%-+-</td>
</tr>
<tr>
<td>NOTIFY</td>
<td>Keyword</td>
</tr>
<tr>
<td>NUMBER</td>
<td>0 through 9 plus .</td>
</tr>
<tr>
<td>NUTLOG</td>
<td>Keyword</td>
</tr>
<tr>
<td>PASSWORD</td>
<td>Keyword</td>
</tr>
<tr>
<td>POLLFREQALERT</td>
<td>Keyword</td>
</tr>
<tr>
<td>POLLFREQ</td>
<td>Keyword</td>
</tr>
<tr>
<td>PORT</td>
<td>Keyword</td>
</tr>
<tr>
<td>POWERVAL</td>
<td>Keyword</td>
</tr>
<tr>
<td>PRINT</td>
<td>Keyword</td>
</tr>
<tr>
<td>QUOTETEXT1</td>
<td>’text’</td>
</tr>
<tr>
<td>QUOTETEXT2</td>
<td>&quot;text&quot;</td>
</tr>
<tr>
<td>QUOTETEXT3</td>
<td>«text»</td>
</tr>
<tr>
<td>QUOTETEXT4</td>
<td>[text]</td>
</tr>
<tr>
<td>QUOTETEXT5</td>
<td>«text»</td>
</tr>
</tbody>
</table>

Figure 119: UPSmon.conf lexer tokens.

<table>
<thead>
<tr>
<th>Token</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>RARR</td>
<td>Symbol -&gt;</td>
</tr>
<tr>
<td>REPORTS</td>
<td>Keyword</td>
</tr>
<tr>
<td>SETFSD</td>
<td>Keyword</td>
</tr>
<tr>
<td>SHELLCMD</td>
<td>Keyword</td>
</tr>
<tr>
<td>SHUTDOWN CMD</td>
<td>Keyword</td>
</tr>
<tr>
<td>SMTPSERVER</td>
<td>Keyword</td>
</tr>
<tr>
<td>STARTTIMER</td>
<td>Keyword</td>
</tr>
<tr>
<td>STATUS</td>
<td>See status list</td>
</tr>
<tr>
<td>SUBJECT</td>
<td>Keyword</td>
</tr>
<tr>
<td>SYSLOG</td>
<td>Keyword</td>
</tr>
<tr>
<td>TIMEOUT</td>
<td>Keyword</td>
</tr>
<tr>
<td>TO</td>
<td>Keyword</td>
</tr>
<tr>
<td>TYPE</td>
<td>Keyword</td>
</tr>
<tr>
<td>UPSDUSER</td>
<td>Keyword</td>
</tr>
<tr>
<td>USER</td>
<td>Keyword</td>
</tr>
<tr>
<td>WALL</td>
<td>Keyword</td>
</tr>
<tr>
<td>WHEN</td>
<td>Keyword</td>
</tr>
<tr>
<td>ignore</td>
<td>Ignore spaces and tabs</td>
</tr>
<tr>
<td>ignore_COMMENT</td>
<td>Ignore #...</td>
</tr>
<tr>
<td>newline</td>
<td>Line counter</td>
</tr>
</tbody>
</table>

Figure 120: UPSmon.conf lexer tokens.
H.2 Yacc Grammar

The grammar shows the logical structure of the configuration file. There is no separate “yacc” grammar file. The productions are represented by functions such as the one shown in figure 121.

Line 806 declares the function providing the grammar production seen in line 807 for the configuration production. The result is tagged with a 3-tuple seen in line 808 giving the identity, line number and column number, and forms the basis for the abstract syntax tree AST. The values for p[1] and p[2] in line 809 are provided by functions p_intros and p_groups.

<table>
<thead>
<tr>
<th>Production</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>configuration : intros groups</td>
<td>Start here</td>
</tr>
<tr>
<td>intros : intro</td>
<td>Start of introduction</td>
</tr>
<tr>
<td></td>
<td>intros intro</td>
</tr>
<tr>
<td>intro : smtp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>let</td>
</tr>
<tr>
<td></td>
<td>pollfreqalert</td>
</tr>
<tr>
<td></td>
<td>pollfreq</td>
</tr>
<tr>
<td>smtp : SMTPSERVER quotetext PORT number</td>
<td></td>
</tr>
<tr>
<td>USER quotetext PASSWORD quotetext</td>
<td></td>
</tr>
<tr>
<td>let : LET name EQ quotetext</td>
<td>battery.charge.low.i for i = 1..3 the name is a special value.</td>
</tr>
<tr>
<td>number : NUMBER</td>
<td></td>
</tr>
<tr>
<td>pollfreqalert : POLLFREQALERT number</td>
<td></td>
</tr>
<tr>
<td>pollfreq : POLLFREQ number</td>
<td>End of the introduction</td>
</tr>
</tbody>
</table>

Figure 122: UPSmon.conf grammar.
... continued

<table>
<thead>
<tr>
<th>groups</th>
<th>group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>groups group_element</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>group_element</th>
<th>group_name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>group_host</td>
</tr>
<tr>
<td></td>
<td>group_port</td>
</tr>
<tr>
<td></td>
<td>certfile</td>
</tr>
<tr>
<td></td>
<td>let</td>
</tr>
<tr>
<td></td>
<td>monitors</td>
</tr>
<tr>
<td></td>
<td>minsupplies</td>
</tr>
<tr>
<td></td>
<td>action_declarations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>group_name</th>
<th>GROUP name</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>NAME</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>group_host</th>
<th>HOST name</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>group_port</th>
<th>PORT number</th>
</tr>
</thead>
</table>

| certfile | CERTFILE quotetext |
|          | CERTFILE name     |

<table>
<thead>
<tr>
<th>monitors</th>
<th>monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>monitors monitor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>monitor</th>
<th>MONITOR name POWERVAL number user</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PASSWORD quotetext TYPE name</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>user</th>
<th>UPSDUSER name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APCUPSDUSER name</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>minsupplies</th>
<th>MINSUPPLIES number</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>action_declarations</th>
<th>action_declaration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>action_declarations action_declaration</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>action_declaration</th>
<th>event_key actions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>event_key</td>
</tr>
<tr>
<td></td>
<td>actions</td>
</tr>
</tbody>
</table>

| event_key          | WHEN name TO name COLON |
|                   | WHEN name TIMEOUT name COLON |
|                   | WHEN name REPORTS STATUS RARR STATUS COLON |

<table>
<thead>
<tr>
<th>actions</th>
<th>action_element</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>actions action_element</td>
</tr>
</tbody>
</table>

Figure 123: UPSmon.conf grammar, continued.
### action_element

- condition cancel_timer
- condition debug_level
- condition email
- condition start_timer
- condition EPRINT quotetexts
- condition NOTIFY quotetexts
- condition NUTLOG quotetexts
- condition PRINT quotetexts
- condition SETFSD name
- condition SHELLCMD quotetexts
- condition SHUTDOWNCMD quotetexts
- condition SYSLOG quotetexts
- condition WALL quotetexts

| condition : IF STATUS RARR STATUS
| empty |

| quotetexts : quotetext
| name |
| quotetexts quotetext |
| quotetexts name |

| quotetext : QUOTETEXT1 |
| QUOTETEXT2 |
| QUOTETEXT3 |
| QUOTETEXT4 |
| QUOTETEXT5 |

| cancel_timer : CANCELTIMER name |

| debug_level : DEBUG number |
| 0, 1 or 2 |

| start_timer : STARTTIMER name number |

| email : EMAIL from to subject content |
| from : FROM quotetext |
| to : TO quotetext |
| subject : SUBJECT quotetext |
| content : MESSAGE quotetexts |

| empty |

---

Figure 124: **UPSmon.conf** grammar, final part.
I  UPSmon.py configuration

A configuration file `UPSmon.conf` must be created to tell `UPSmon.py` how to handle the status changes coming from `upsd`. As with `upsmon.conf`, this can be done manually, but for simple cases, probably the majority, in which `upsd` and `UPSmon.py` run in the same machine, `UPSmon.py` provides a Python3 tool `mkUPSmonconf.py`, to create a complete fully functioning configuration file. You can either use the output of this tool or take it as the starting point for a customised configuration.

I.1  Configuration tool `mkUPSmonconf.py` version 1.3

```bash
$ mkUPSmonconf.py --help
```

Figure 125: Command `mkUPSmonconf.py --help`.

`mkUPSmonconf.py` is a Python3 script which will build a simple configuration file `UPSmon.conf` for `UPSmon.py`. The script proposes a possible configuration file based on it’s built-in default values and asks for your approval. Here is a fanciful example.

```bash
$ mkUPSmonconf.py
Here are your chosen values:
--configurationfile /etc/nut/UPSmon.conf
--clientcertfile /etc/nut/titan-client.cert.pem
--emailfrom "<bigserver@BigU.edu>"
--emailto "Big Joe <jschmo@BigU.edu>"
--plan timed
--smtpserver "mailbox@mailserver,com"
--smtpport 465
--smtpuser jschmo
--smtppass qwertyuiop
--ups UPS-123
--upsdname localhost
--upsdport 401
--upsduser nut-admin
--upsdpass sekret
If this configuration is correct, enter yes to proceed, anything else to exit:
```
If the proposed configuration values are satisfactory, you reply **yes**, but if they are not right for you, you hit **Enter** and rerun the script using the options to specify your preferred values.

The status is “experimental”. The script is intended for demonstration and experiment. The license is GPL v3 or later at your choice, with support in the [nut-upsuser mailing list](mailto:nut-upsuser@lists.nongnu.org).

Let’s look at these arguments in more detail.

**-h, --help**  
Show this help message and exit.

**--configurationfile <filename>**  
The file which holds **UPSmon.py**’s configuration. E.g. A Debian sysadmin might use `/etc/nut/UPSmon.conf`

**--clientcertfile <filename>**  
The file which holds the client’s public TLS certificate required to access the server **upsd**, possibly with **upsdTLS.py**. E.g. A Debian sysadmin might use `/etc/nut/bigbox-client.cert.pem`

**--emailfrom <string>**  
The email address from which messages will be sent.  
E.g. "<bigserver@bigU.edu>" Note the email convention of placing the address in angle brackets, and the double quotes needed to prevent Bash from interpreting the angle brackets.

**--emailto <string>**  
The email address of the person to whom messages will be sent.  
E.g. "Big Joe <jschmoe@bigU.edu>" Note the email convention of placing the address in angle brackets, and the double quotes needed to prevent Bash from interpreting the angle brackets.

**--plan standard|timed**  
Specify standard or timed shutdown plan. Valid options are **standard** or **timed**.

**--smtppass <string>**  
The password for your account on the e-mail server. E.g. **qwertyuiop**. This definitely needs changing.

**--smtpport <integer>**  
Your e-mail server’s TLS port. E.g. **465**. Communication with the mail server is always TLS encrypted.

**--smtpserver <domain>**  
Your e-mail server.  
E.g. **mailbox.mailserver.com**

**--smtpuser <name>**  
Your sign-in account name on the e-mail server.  
E.g. **mailbox@mydomain.com**

**--ups <name>**  
The name of your UPS, for example **UPS_123**. If you have more than one UPS unit then create a configuration file for the first, and then extend it using copy/paste of the actions for the second.

**--upsdname <name>**  
The name of the system on which **upsd** runs. E.g. **localhost** if **UPSmon.py** and **upsd** run on the same machine.
--upsdpass <string>   The password for this upsd user, as given in upsd.users.
                   Do you remember the password = sekret on line 41?

--upsdport <integer> The TLS port used by upsd possibly with shim upsdTLS.py. E.g. 401

--upsduser <name>    User for this UPS, as given in upsd.users. E.g. nut-admin on line 40

-v, --version        Show program and Python versions, then exit.

I.2  **UPSmon.conf** configuration examples

Let’s look at a shutdown plan generated by mkUPSmonconf.py.

I.2.1  Timed shutdown plan, part 1 of 4, the introduction

```plaintext
# UPSmon.conf timed shutdown plan generated by mkUPSmonconf.py version 1.3
# on 2022-09-03 17:18:48.202107
# Python version 3.9.2 (default, Feb 28 2021, 17:03:44) [GCC 10.2.1 20210110]
# Calling command:
./mkUPSmonconf.py --plan timed --ups UPS-1 --upsdname localhost --upsdport 401
--clientcertfile /etc/nut/titan-client.cert.pem --upsduser nut-admin
--upsdpass sekret --smtpserver mail.gandi.net --smtpport 465 --smtppass qwerty
--smtpuser mailbox@rogerprice.org --configurationfile /etc/nut/UPSmon.conf
--emailfrom "<UPSmon@rogerprice.org>" --emailto "Price <roger@rogerprice.org>"
# Support: nut-upsuser mailing list.

# All groups share the same POLLFREQ and POLLFREQALERT and e-mail relay
POLLFREQ 5.0  POLLFREQALERT 5.0
SMTPSERVER «mail.gandi.net» PORT 465
USER «mailbox@rogerprice.org» PASSWORD «qwertyuiop»

# Named messages Let hostname = hostname is built in.
LET banner = "[%(b)s] UPS=%(u)s charge=%(c)s event=%(e)s"
LET Msg-COMM = banner " I have re-established communication with this UPS."
LET Msg-NOCOMM = banner " I have lost communication with this UPS."
LET Msg-OL = banner " Power restored, shutdown cancelled."
LET Msg-RB = banner " Battery needs replacement."
LET Msg-shutdown = banner " On battery, shutting down now ..."
LET Certfile = «/etc/nut/titan-client.cert.pem»
```

Figure 126: Timed shutdown plan, part 1 of 4, the introduction.
Notes on figure 126

1. The command used to generate the file is repeated on line 836.
2. The \texttt{POLLFREQ} and \texttt{POLLFREQALERT} on line 840 are the same as \texttt{upsmon}. See chapter 4.1.
3. On line 841 the \texttt{PORT} number corresponds to a TLS port. Communication with the email service provider is always TLS encrypted.
4. On lines 841-842 the \texttt{...} is added automatically by the \texttt{mkUPSmonconf.py} script. You do not have to do this.
5. Line 850 corresponds to a Debian installation. See table 104 for a list of possible directories.

\subsection{Timed shutdown plan, part 2 of 4, the shutdown}

```plaintext
# The local UPS units
GROUP LOCAL HOST localhost PORT 401 CERTFILE Certfile
MONITOR UPS-1 POWERVAL 1 UPSDUSER nut-admin PASSWORD <sekret> TYPE primary

# Timed plan additional messages and actions
LET Msg-2-min = banner "On battery, shutdown in 2 mins, save your work ..."
LET Msg-1-min = banner "On battery, shutdown in 1 min, save your work ..."
WHEN UPS-1 REPORTS OL->OB : NOTIFY Msg-2-min NUTLOG Msg-2-min
STARTTIMER two-min 120 STARTTIMER one-min 60
WHEN UPS-1 TIMEOUT one-min : NOTIFY Msg-1-min NUTLOG Msg-1-min WALL Msg-1-min
EMAIL FROM <UPSmon@rogerprice.org> 
    TO <Roger Price <roger@rogerprice.org> > 
    SUBJECT <Msg-1-min>
    MESSAGE <Msg-1-min>
WHEN UPS-1 TIMEOUT two-min : NOTIFY Msg-shutdown NUTLOG Msg-shutdown
    WALL Msg-shutdown STARTTIMER final-delay 5
WHEN UPS-1 REPORTS OB->OL : NOTIFY Msg-OL NUTLOG Msg-OL WALL Msg-OL
    CANCELTIMER two-min CANCELTIMER one-min
    CANCELTIMER final-delay

# End of timed plan additional actions

# Shutdown on low battery
WHEN UPS-1 REPORTS None->LB : NOTIFY Msg-shutdown NUTLOG Msg-shutdown
    WALL MSG-shutdown STARTTIMER final-delay 5
WHEN UPS-1 TIMEOUT final-delay : SHUTDOWNCMD "/sbin/shutdown -h 0"
```

Figure 127: Timed shutdown plan, part 2 of 4, the shutdown.
1. Line 852 introduces the notion of “GROUP”. In general a group is a set of UPS units which are attached to the same upsdd server. In NUT’s upsmon.conf the MONITOR system declaration identifies the upsdd host system and the port. See man upsmon.conf. UPSmon.conf transfers the host system and port identification to a named group, and adds the CERTFILE declaration.

2. Line 853 resembles the upsmon.conf declaration, but with the inclusion of additional keywords for clarification. “UPS-1” declares the UPS name, the HOST and PORT have already been declared. The UPS name should correspond to the name specified in ups.conf. See line 32.

3. Since this is the timed plan rather than the standard plan, we need additional messages which are declared on lines 855-856.

4. When event OL->OB arrives, lines 857-858 call for the “on battery” message to be put on-screen and in the NUT log file. The actions also declare the timers two-min and one-min and start them.

5. When timer one-min runs out, lines 859-863 place warnings on screen, in the NUT log file and on all logged in terminals. The actions also send an email to the administrator.

6. When timer two-min runs out, lines 864-865 place warnings on-screen, in terminals and in the NUT log file. A short final-delay timer is declared and started. This timer corresponds to FINALDELAY in upsmon.conf.

7. What happens if power returns before the shutdown? If event OB->OL arrives, lines 866-867 notify the user, place a message in the NUT log file and turn off all the timers.

8. Whether the plan is “standard” or “timed” the local system must be shutdown on event None ->LB. This happens on lines 870-871. Users receive a final on-screen warning, a message goes into the NUT log file and the action declares and starts a short final-delay timer.

9. When the final-delay timer runs out, line 872 calls for a system shutdown.

I.2.3 Timed shutdown plan, part 3 of 4, warnings

Notes on figure 128

1. Some UPS units are capable of reporting that the battery needs replacement. On line 874, when event None->RB arrives, messages are placed on-screen and in the NUT log file. Line 876 sends an email to the sysadmin. The upsmon RBWARNTIME behaviour is reproduced by defining and starting an rbwarntime timer.

2. Line 880 specifies that when the rbwarntime timer runs out, an on-screen message appears\(^{37}\) and also goes into the NUT log file. The action also restarts the timer. It will continue to loop until the status [RB] disappears with event RB->None on line 881.

\(^{37}\)Do the users have to be told about this?
# Warning for battery replacement

WHEN UPS-1 REPORTS None->RB : STARTTIMER rbwarntime 43200

NUTLOG Msg-RB NOTIFY Msg-RB

EMAIL FROM <UPSmon@rogerprice.org> 
    TO <Roger Price <roger@rogerprice.org> >
    SUBJECT <Msg-RB>
    MESSAGE <Msg-RB>

WHEN UPS-1 TIMEOUT rbwarntime : STARTTIMER rbwarntime 43200

NUTLOG Msg-RB NOTIFY Msg-RB

WHEN UPS-1 REPORTS RB->None : CANCELTIMER rbwarntime

# Warning that UPSmon has lost UPS UPS-1. Shut down on NOCOMM when OB.

WHEN UPS-1 REPORTS COMM->NOCOMM : STARTTIMER nocommwarntime 300

IF OL->OB NOTIFY Msg-shutdown

IF OL->OB NUTLOG Msg-shutdown

IF OL->OB WALL Msg-shutdown

IF OL->OB STARTTIMER final-delay 5

WHEN UPS-1 TIMEOUT nocommwarntime : NUTLOG Msg-NOCOMM NOTIFY Msg-NOCOMM

WHEN UPS-1 REPORTS NOCOMM->COMM : CANCELTIMER nocommwarntime

NUTLOG Msg-COMM NOTIFY Msg-COMM

Figure 128: Timed shutdown plan, part 3 of 4, warnings,

3. The statuses [COMM] and [NOCOMM] are not due to upsd. They are generated internally by UPSmon.py when it has problems talking to upsd. The standard and timed configurations discussed here have been tested with upsd and UPSmon.py running in the same machine, but in general this is not the case, and network problems become more apparent when upsd and UPSmon.py are separated.

The event COMM->NOCOMM starts a timer which will later place a warning message in front of users and in the NUT log file. This follows the upsmón logic. Additionally, and again following upsmón logic, a shutdown procedure will begin if the system is currently running on battery. See lines 884-887. Note that the condition must be attached to each of the actions.

Note the subtle difference between upsmón and UPSmon.py. See figure 15. On line 68 daemon upsmón will trigger a [NOCOMM] NOTIFY event after NOCOMMWARNTIME seconds if it can't reach any of the UPS entries in configuration file upsmón.conf. UPSmon.py does this for each UPS individually. The difference is slight if there is only one UPS :-)

4. On line 889 the timer nocommwarntime is cancelled and suitable messages send to the users and the NUT log file.

\[38\] Is it really necessary to notify the users of this technical matter?
I.2.4 Timed shutdown plan, part 4 of 4, heartbeat

The NUT software runs in the background for weeks, months without difficulty and with no messages going the system administrator. “All is well!”, but is it?

NUT is a collection of pieces and interconnecting protocols. What if one of these pieces has stopped or the protocol blocked? We need something that will check regularly that all is indeed well. The proposed heartbeat does this job.

Heartbeat definitions are not provided by NUT, you have to create them for yourself. Create the new file heartbeat.conf as shown in figure 129 in the same directory as ups.conf. As called for by line 899, the heartbeat will cycle continuously through this script.

For good security, only users ups/d/nut and root should have write access to this file.

Lines 892 and 894 flip the ups.status value between [TICK] and [TOCK].

Lines 893 and 895 place a 10 minute time interval between each status change. $2 \times 600 \text{sec} = 20 \text{min}$, the heartbeat period.

You must also declare to ups/d that it is to generate the heartbeat. Add the declaration shown in figure 130 to file ups.conf. In line 897 we see the driver used to generate the heartbeat. This driver is also used for debugging. You can amuse yourself by adding further status changes and observing their effect.

Notes on figure 131:

1. On line 904 a group “HB” is declared to contain the heartbeat UPS. The HOST, PORT and CERTFILE are the same as for the physical UPS.
2. Lines 905-906 declare messages specific to the heartbeat.
3. Other than the POWERVAL of 0, the MONITOR declaration on line 907 is the same as for the physical UPS.
4. Line 908 says that the heartbeat does not require electrical energy. This zero declaration also circumvents certain sanity checks that real UPS’s must pass.
5. Lines 909 and 912 manage the timers which watch over the [TICK] and [TOCK] coming from ups/d. The timer is longer than the expected interval between status arrivals. If this timer expires we assume that the heartbeat has failed.
6. If you uncomment the logging of the None->TICK on line 911 then your log will grow rapidly with a message every 20 minutes.
7. Line \texttt{914} is a form of “goto” so all the heartbeat error logging is in one place.

8. Lines \texttt{915-919} send heartbeat failure messages to the system administrator and to the NUT log file.

```plaintext
# Heartbeat operation, requires file heartbeat.conf in the upsd server,
# and definition of UPS [heartbeat] in ups.conf. Note that the timer
# specified here must be longer than the timer in heartbeat.conf.
GROUP HB HOST localhost PORT 401 CERTFILE Certfile
LET Msg-HB-start = banner " Event \%(e)s Start HB-timer"
LET MSG-HB-fails = banner " \%(u)s FAILURE."
   " I have not received expected TICK/TOCK status change."
MONITOR heartbeat POWERVAL 0 UPSDUSER nut-admin PASSWORD «sekret» TYPE primary
MINSUPPLIES 0
WHEN heartbeat REPORTS None->TICK : CANCELTIMER tock-timer
STARTTIMER tick-timer 660
# NUTLOG Msg-HB-start
WHEN heartbeat REPORTS None->TOCK : CANCELTIMER tick-timer
STARTTIMER tock-timer 660
# What to do if the heartbeat fails
WHEN heartbeat TIMEOUT tick-timer : STARTTIMER tock-timer 0.5
WHEN heartbeat TIMEOUT tock-timer : NUTLOG MSG-HB-fails NOTIFY MSG-HB-fails
EMAIL FROM « UPSmon@rogerprice.org »
TO « Price <roger@rogerprice.org> »
SUBJECT «Msg-HB-fails»
MESSAGE «Msg-HB-fails»
# End of file
```

Figure 131: Timed shutdown plan, part 4 of 4, heartbeat.

### I.2.5 Standard shutdown plan

The only differences between the standard plan and the timed shutdown plan are that the standard plan removes lines \texttt{854-868} and replaces them with lines \texttt{922-923} These actions send a warning message to the users and to the NUT log file.

```plaintext
# Standard plan specific actions
LET Msg-OB = banner " Power failure, possible shutdown, save your work ..."
WHEN UPS-1 REPORTS OL->OB : NOTIFY Msg-OB NUTLOG Msg-OB WALL Msg-OB
# End of standard plan specific actions
```

Figure 132: Standard shutdown plan differences
I.3 Redundant power supplies

Please see section 3 and sections “Power values” and “Redundant power supplies” in man upsmon. The upsmon logic is built into the code rather than the configuration file and follows the spirit of the standard shutdown plan preferred by upsmon.

UPSmon.py allows the system administrator to customise the logic using the configuration file.

I.3.1 MINSUPPLIES failure: Timed shutdown plan

The configuration for a timed shutdown plan for redundant power supplies is very similar to a None -> OB timed shutdown: the status [LS] meaning “Low Supplies” replaces the status [OB]. [LS] says that within a given group, the total powervalue of the UPS units with status [OL] is not sufficient to meet the MINSUPPLIES criterion.

```
925 # Timed shutdown on MINSUPPLIES failure
926 LET Msg-LS = banner " Powervalue failure. MINSUPPLIES not satisfied."
927 WHEN UPS-1 REPORTS None->LS : NOTIFY Msg-LS NUTLOG Msg-LS WALL Msg-LS
928     EMAIL FROM « <UPSmon@rogerprice.org> »
929         TO « Roger Price <roger@rogerprice.org> »
930         SUBJECT «Msg-LS»
931         MESSAGE «Msg-LS»
932         NOTIFY Msg-2-min NUTLOG Msg-2-min WALL Msg-2-min
933         STARTTIMER two-min 120 STARTTIMER one-min 60
934 WHEN UPS-1 REPORTS LS->None : NOTIFY Msg-OL NUTLOG Msg-OL WALL Msg-OL
935         CANCELTIMER two-min CANCELTIMER one-min
936         CANCELTIMER final-delay
```

Figure 133: Timed shutdown on MINSUPPLIES failure

I.3.2 MINSUPPLIES failure: Standard shutdown plan

Shutting down a redundant system using the upsmon logic of waiting for [LB] is left as as exercise for the reader. If that’s what you really want, why not go on using upsmon?
Here is the editor’s checklist of the things to do to install and run UPSmon.py.

1. Check that you have Python 3.6, or more recent, running. No? You will need to install it.
2. Check that you have OpenSSL 1.1.1d or better.
3. Download UPSmon.py, upsdTLS.py, mkNUTcert.py and mkUPSmonconf.py from rogerprice.org/NUT to wherever you put Python3 scripts.
4. Review the shebangs at the top of the Python3 scripts. Modify if needed to meet the local situation. The shebangs that come with the scripts are those used by the editor. Yours may well be different.
5. Create symlink from /usr/sbin/UPSmon.py to wherever you put the Python3 scripts. Create similar links for upsdTLS.py, mkNUTcert.py and mkUPSmonconf.py.
6. Install the systemd service unit /etc/systemd/system/nut-py-server-shim.service and the /etc/systemd/system/nut-py-monitor.service service unit. See section 12.4
7. Add programs shutdown, wall and notify-send to /etc/sudoers for users nut/upsd. See section D.2
8. Run mkNUTcert.py to make TLS certificates. See chapter 10.
9. Run mkUPSmonconf.py to create the UPSmon.py configuration file. See section I.1
10. Install /etc/logrotate.d/NUT. See appendix E
11. Check that heartbeat.conf is installed in the upsd machine and that ups.conf contains a [heartbeat] declaration.
12. Stop and disable the nut-monitor service unit.
13. Run systemctl daemon-reload and enable the nut-py-server-shim service unit and the nut-py-monitor service unit. Start the nut-py-server-shim and then the nut-py-monitor service units.
14. Check output of command ps -elf | grep -E "nut|upsd" which on an openSUSE machine gives the output shown in figure 134.

Figure 134: upsd and UPSmon.py runtime processes

Questions? Try the nut-upsuser mailing list
Part 5

The End

K  Acknowledgments

Editor: As one of the many who have used the work of the NUT project as part of their system setup, I would like to express my gratitude and my appreciation for the software that the NUT project has made available to system administrators through contributions by Charles Lepple, Arjen de Korte, Arnaud Quette, Jim Klimov, Russell Kroll, and many others in the nut-upsuser mailing list.

I would also like to thank those who commented on earlier versions of this text: M.B.M.

L  Errors, omissions, obscurities, confusions, typos...

Please signal errors, omissions, typos and all the other problems you find in this document in the nut-upsuser mailing list. Thank you.  

Joe’s server will still be alright if power drops off in the night.  
That 8 year old pack of battery back-up will easily handle the connection lost