Piwheels 0.17 Documentation

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Contents

1 Overview 1

2 piw-master 3

3 piw-slave 7

4 piw-monitor 9

5 piw-sense 11

6 piw-initdb 13

7 piw-import 15

8 piw-rebuild 17

9 piw-remove 19

10 piw-logger 21

11 Development 23

12 Module Reference 37

13 License 61

Python Module Index 63

Index 65

CHAPTER 1

Overview

The piwheels project is designed to automate building of wheels from packages on PyPI for a set of pre-configured ABIs. As the name suggests, it was originally built for Raspberry Pis but there's nothing particular in the codebase that should limit it to that platform. The system relies on the following components:

Component	Description
piw-master (page 3)	Coordinates the various build slaves, using the database to store all relevant information, and keeps the web site up to date.
piw-slave (page 7)	Builds package on behalf of the piwheels master. Is intended to run on separate machines to the master, partly for performance and partly for security.
piw-monitor (page 9)	Provides a friendly curses-based UI for interacting with the piwheels master.
piw-sense (page 11)	Provides a friendly Sense HAT-based UI for interacting with the piwheels master.
piw-initdb (page 13)	A simple maintenance script for initializing or upgrading the database to the current version.
piw-import (page 15)	A tool for importing wheels manually into the piwheels database and file-system.
piw-remove (page 19)	A tool for manually removing builds from the database and file-system.
piw-rebuild (page 17)	A tool for regenerating certain elements of the piwheels web-site.
piw-logger (page 21)	A tool for transferring download statistics into the piwheels database.
database server	Currently only PostgreSQL[1] is supported (and frankly that's all we're ever likely to support). This provides the master's data store.
web server	Anything that can serve from a static directory is fine here. We use Apache[2] in production.

Note: At present the master is a monolithic application, but the internal architecture is such that it could, in future, be split into three parts: one that deals exclusively with the database server, one that deals exclusively with the file-system served by the web server, and one that talks to the piwheels slave and monitor processes.

[1] https://postgresql.org/
[2] https://httpd.apache.org/

CHAPTER 2

piw-master

The piw-master script is intended to be run on the database and file-server machine. It is recommended you do not run piw-slave on the same machine as the piw-master script. The database specified in the configuration must exist and have been configured with the piw-initdb script. It is recommended you run piw-master as an ordinary unprivileged user, although obviously it will need write access to the output directory.

2.1 Synopsis

```
piw-master [-h] [--version] [-c FILE] [-q] [-v] [-l FILE] [-d DSN]
                [-o PATH] [--dev-mode] [--pypi-xmlrpc URL]
                [--pypi-simple URL] [--status-queue ADDR]
                [--control-queue ADDR] [--import-queue ADDR]
                [--log-queue ADDR] [--slave-queue ADDR] [--file-queue ADDR]
                [--web-queue ADDR] [--builds-queue ADDR] [--db-queue ADDR]
                [--fs-queue ADDR] [--stats-queue ADDR]
```

2.2 Description

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

--version
Show program's version number and exit

-c FILE, **--configuration** FILE
Specify a configuration file to load

-q, --quiet
Produce less console output

-v, --verbose
Produce more console output

-l FILE, **--log-file** FILE
Log messages to the specified file

-d DSN, **--dsn** DSN
: The database to use; this database must be configured with piw-initdb and the user must *not* be a PostgreSQL[3] superuser (default: postgres:///piwheels)

-o PATH, **--output-path** PATH
: The path under which the website should be written; must be writable by the current user

--dev-mode
: Run the master in development mode, which reduces some timeouts and tweaks some defaults

--pypi-xmlrpc URL
: The URL of the PyPI XML-RPC service (default: https://pypi.python.org/pypi)

--pypi-simple URL
: The URL of the PyPI simple API (default: https://pypi.python.org/simple)

--status-queue ADDR
: The address of the queue used to report status to monitors (default: ipc:///tmp/piw-status); this is usually an ipc address

--control-queue ADDR
: The address of the queue a monitor can use to control the master (default: ipc:///tmp/piw-control); this is usually an ipc address

--import-queue ADDR
: The address of the queue used by *piw-import* (page 15) (default: ipc:///tmp/piw-import); this should always be an ipc address

--log-queue ADDR
: The address of the queue used by *piw-logger* (page 21) (default: ipc:///tmp/piw-logger); this should always be an ipc address

--slave-queue ADDR
: The address of the queue used to talk to the build slaves (default: tcp://*:5555); this is usually a tcp address

--file-queue ADDR
: The address of the queue used to transfer files from slaves (default: tcp://*:5556); this is usually a tcp address

--builds-queue ADDR
: The address of the queue used to store pending builds (default: inproc://builds)

--db-queue ADDR
: The address of the queue used to talk to the database server (default: inproc://db)

--fs-queue ADDR
: The address of the queue used to talk to the file- system server (default: inproc://fs)

--stats-queue ADDR
: The address of the queue used to send statistics to the collator task (default: inproc://stats)

2.3 Deployment

A typical deployment of the master service on a Raspbian server goes something like this (each step assumes you start as root):

1. Install the pre-requisite software:

```
# apt install postgresql-9.6 apache2 python3-psycopg2 python3-geoip
# apt install python3-sqlalchemy python3-urwid python3-zmq python3-voluptuous␣
↪python3-chameleon
# pip install piwheels[monitor,master,logger]
```

[3] https://postgresql.org/

2. Set up the (unprivileged) piwheels user and the output directory:

```
# groupadd piwheels
# useradd -g piwheels -m piwheels
# mkdir /var/www/piwheels
# chown piwheels:piwheels /var/www/piwheels
```

3. Set up the database:

```
# su - postgres
$ createuser piwheels
$ createdb -O postgres piwheels
$ piw-initdb
```

4. Set up the web server:
   - Point the document root to the output path (`/var/www/piwheels` above, but it can be anywhere your piwheels user has write access to; naturally you want to make sure your web-server's user only has *read* access to the location).
   - Set up SSL for the web server (e.g. with Let's Encrypt[4]; the dehydrated[5] utility is handy for getting and maintaining the SSL certificates).
5. Start the master running (it'll take quite a while to populate the list of packages and versions from PyPI on the initial run so get this going before you start bringing up build slaves):

```
# su - piwheels
$ piw-master -v
```

6. Deploy some build slaves; see *piw-slave* (page 7) for deployment instructions.

2.4 Automatic start

If you wish to ensure that the master starts on every boot-up, you may wish to define a systemd unit for it. Example units can be also be found in the root of the piwheels repository:

```
# wget https://raw.githubusercontent.com/piwheels/piwheels/master/piwheels-master.
↪service
# cp piwheels-master.service /etc/systemd/system/
# systemctl daemon-reload
# systemctl enable piwheels-master
# systemctl start piwheels-master
```

2.5 Upgrades

The master will check that build slaves have the same version number and will reject them if they do not. Furthermore, it will check the version number in the database's *configuration* table matches its own and fail if it does not. Re-run the *piw-initdb* (page 13) script as the PostgreSQL super-user to upgrade the database between versions (downgrades are not supported, so take a backup first!).

[4] https://letsencrypt.org/
[5] https://github.com/lukas2511/dehydrated

CHAPTER 3

piw-slave

The piw-slave script is intended to be run on a standalone machine to build packages on behalf of the piw-master script. It is intended to be run as an unprivileged user with a clean home-directory. Any build dependencies you wish to use must already be installed. The script will run until it is explicitly terminated, either by Ctrl+C, SIGTERM, or by the remote piw-master script.

3.1 Synopsis

```
piw-slave [-h] [--version] [-c FILE] [-q] [-v] [-l FILE] [-m HOST]
          [-t DURATION]
```

3.2 Description

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

--version
Show program's version number and exit

-c FILE, **--configuration** FILE
Specify a configuration file to load

-q, --quiet
Produce less console output

-v, --verbose
Produce more console output

-l FILE, **--log-file** FILE
Log messages to the specified file

-m HOST, **--master** HOST
The IP address or hostname of the master server (default: localhost)

-t DURATION, **--timeout** DURATION
The time to wait before assuming a build has failed (default: 3h)

3.3 Deployment

Our typical method of deployment is to spin up a new Pi as a build slave (through Mythic Beasts' control panel) then execute a script to install the piwheels code, and all the build dependencies that we feel are reasonable to support under various Raspbian versions. The deployment script can be found in the root of the piwheels repository:

```
# wget https://raw.githubusercontent.com/piwheels/piwheels/master/deploy_slave.sh
# chmod +x deploy_slave.sh
# ./deploy_slave.sh
```

However, you will very likely wish to customize this script for your own purposes, e.g. to support a different set of dependencies, or to customize the typical build environment.

Once the script is complete, simply switch to the unprivileged user used to run the build slave, and execute *piw-slave* (page 7). For example, assuming the master's IP address is 10.0.0.1:

```
# su - piwheels
$ piw-slave -m 10.0.0.1
```

3.4 Automatic start

If you wish to ensure that the build slave starts on every boot-up, you may wish to define a systemd unit for it. Example units can be also be found in the root of the piwheels repository:

```
# wget https://raw.githubusercontent.com/piwheels/piwheels/master/piwheels-slave.
↪service
# cp piwheels-slave.service /etc/systemd/system/
# systemctl daemon-reload
# systemctl enable piwheels-slave
# systemctl start piwheels-slave
```

Warning: Be aware that this example unit forces a reboot in the case that the build slave fails (as occasionally happens with excessively complex packages).

Because of this you *must* ensure that the slave executes successfully prior to installing the unit, otherwise you're liable to leave your build slave in permanent reboot cycle. This isn't a huge issue for a build slave that's physically in front of you (from which you can detach and tweak the storage), but it may be an issue if you're dealing with a cloud builder.

CHAPTER 4

piw-monitor

The piw-monitor application is used to monitor (and optionally control) the piw-master script. Upon startup it will request the status of all build slaves currently known to the master, and will then continually update its display as the slaves progress through builds. The controls at the bottom of the display allow the administrator to pause or resume the master script, kill build slaves that are having issues (e.g. excessive resource consumption from a huge build) or terminate the master itself.

4.1 Synopsis

```
piw-monitor [-h] [--version] [-c FILE] [--status-queue ADDR]
            [--control-queue ADDR]
```

4.2 Description

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

--version
Show program's version number and exit

-c FILE, **--configuration** FILE
Specify a configuration file to load

--status-queue ADDR
The address of the queue used to report status to monitors (default: ipc:///tmp/piw-status)

--control-queue ADDR
The address of the queue a monitor can use to control the master (default: ipc:///tmp/piw-control)

4.3 Usage

The monitor application should be started on the same machine as the master after the *piw-master* (page 3) script has been started. After initialization it will request the current status of all build slaves from the master, displaying this in a list in the middle of the screen.

The `Tab` key can be used to navigate between the list of build slaves and the controls at the bottom of the screen. Mouse control is also supported, provided the terminal emulator supports it. Finally, hot-keys for all actions are available. The actions are as follows:

4.3.1 Pause

Hotkey: `p`

Pauses operations on the master. This causes *Cloud Gazer* (page 24) to stop querying PyPI, *Slave Driver* (page 25) to return "SLEEP" in response to any build slave requesting new packages, and so on. This is primarily a debugging tool to permit the developer to peek at the system in a more or less frozen state before resuming things.

4.3.2 Resume

Hotkey: `r`

Resumes operations on the master when paused.

4.3.3 Kill Slave

Hotkey: `k`

The next time the selected build slave requests a new package (with "IDLE") the master will return "BYE" indicating the slave should terminate. Note that this cannot kill a slave in the middle of a build (that would require a more complex asynchronous protocol in *Slave Driver* (page 25)), but is useful for shutting things down in an orderly fashion.

4.3.4 Terminate Master

Hotkey: `t`

Tells the master to shut itself down. In a future version, the master *should* request all build slaves to terminate as well, but currently this is unimplemented.

4.3.5 Quit

Hotkey: `q`

Terminate the monitor. Note that this won't affect the master.

CHAPTER 5

piw-sense

The piw-sense application is an alternative monitor for the piw-master script that uses the Raspberry Pi Sense HAT as its user interface. Upon startup it will request the status of all build slaves currently known to the master, and will then continually update its display as the slaves progress through builds. The Sense HAT's joystick can be used to navigate information about current builds, and kill builds slaves that are having issues, or terminate the master itself.

5.1 Synopsis

```
piw-sense [-h] [--version] [-c FILE] [--status-queue ADDR]
               [--control-queue ADDR] [-r DEGREES]
```

5.2 Description

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

--version
Show program's version number and exit

-c FILE, **--configuration** FILE
Specify a configuration file to load

--status-queue ADDR
The address of the queue used to report status to monitors (default: ipc:///tmp/piw-status)

--control-queue ADDR
The address of the queue a monitor can use to control the master (default: ipc:///tmp/piw-control)

-r DEGREES, **--rotate** DEGREES
The rotation of the HAT in degrees; must be 0 (the default), 90, 180, or 270

5.3 Usage

The Sense monitor can be started on the same machine as the master after the *piw-master* (page 3) script has been started. After initialization it will request the current status of all build slaves from the master.

5.3.1 Layout

The top three (normally blue) rows of the display are used for some important statistics:

- The top row represents the ping time from the master, or more specifically the time since the last message was received. This will continually increase (changing white), and reset with each message received. If 30 seconds elapse without any messages being received, this row will pulse red until another message is received, resetting the count.
- The second row represents available disk space for the output directory on the master. White pixels represent remaining space, and the scale is simply percentage (all blue = 0%, all white = 100%).
- The third row represents the number of pending builds on the master. The scale is one white pixel = 8 builds in the queue (with partial shades representing <8 builds).

The remaining rows represent all build slaves. Each pixel represents a single build slave, working vertically then horizontally. Build slaves are sorted first by ABI, then by label (as in *piw-monitor* (page 9)).

- A gray pixel indicates an idle build slave.
- A green pixel indicates an active build.
- A blue pixel indicates an active file transfer after a successful build.
- A purple pixel indicates a build slave cleaning up after a build.
- A yellow pixel indicates an active build that's been running for more than 15 minutes; not necessarily a problem but longer than average.
- A red pixel indicates a build slave that's either timed out or been terminated; it should disappear from the display within a few seconds.

5.3.2 Navigation

The pixel that pulses white indicates your current position, which can be moved with the Sense HAT joystick. Pressing the joystick in when a build-slave is selected (indicated by it pulsing white) will bring up detailed information on that build slave.

Scroll left and right to navigate through the build-slave information (label, ABI, current task, and kill option). Press the joystick in to return to the main display (optionally killing the build slave if the kill screen is selected).

Scroll the cursor off the top of the display to go to detailed statistics information. Scroll left and right to navigate through the available statistics (ping time, disk free, queue size, build rate, total build time, and total build size). Most statistics are displayed as scrolling text, and a background fill representing the information graphically. Scroll down to return to the main screen.

Scroll the cursor off the bottom of the display to go to the quit and terminate options (scroll left and right to navigate between them). Press the joystick in to activate either option, or scroll up to return to the main screen.

CHAPTER 6

piw-initdb

The piw-initdb script is used to initialize or upgrade the piwheels master database. The target PostgreSQL[6] database must already exist, and the DSN should connect as a cluster superuser (e.g. the postgres user), in contrast to the piw-master script which should *not* use the cluster superuser. The script will prompt before making any permanent alterations, and all actions will be executed within a single transaction so that in the event of failure the database will be left unchanged. Nonetheless, it is strongly recommended you take a backup of your database before using this script for upgrades.

6.1 Synopsis

```
piw-initdb [-h] [--version] [-c FILE] [-q] [-v] [-l FILE] [-d DSN]
           [-u NAME] [-y]
```

6.2 Description

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

--version
show program's version number and exit

-c FILE, **--configuration** FILE
Specify a configuration file to load

-q, --quiet
produce less console output

-v, --verbose
produce more console output

-l FILE, **--log-file** FILE
log messages to the specified file

[6] https://postgresql.org/

-d DSN, **--dsn** DSN
: The database to create or upgrade; this DSN must connect as the cluster superuser (default: postgres:///piwheels)

-u NAME, **--user** NAME
: The name of the ordinary piwheels database user (default: piwheels); this must *not* be a cluster superuser

-y, **--yes**
: Proceed without prompting before init/upgrades

6.3 Usage

This script is intended to be used after installation to initialize the piwheels master database. Note that it does *not* create the database or the users for the database. It merely creates the tables, views, and other structures within an already existing database. See the *Overview* (page 1) chapter for typical usage.

The script can also be used to upgrade an existing piwheels database to the latest version. The update scripts used attempt to preserve all data, and all upgrades are performed in a single transaction so that, theoretically, if anything goes wrong the database should be rolled back to its original state. However, it is still strongly recommended that you back up your master database before proceeding with any upgrade.

CHAPTER 7

piw-import

The piw-import script is used to inject the specified file(s) manually into the piwheels database and file-system. This script must be run on the same node as the piw-master script. If multiple files are specified, they are registered as produced by a *single* build.

7.1 Synopsis

```
piw-import [-h] [--version] [-c FILE] [-q] [-v] [-l FILE]
           [--package PACKAGE] [--package-version VERSION] [--abi ABI]
           [--duration DURATION] [--output FILE] [-y] [-d]
           [--import-queue ADDR]
           files [files ...]
```

7.2 Description

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

--version
Show program's version number and exit

-c FILE, **--configuration** FILE
Specify a configuration file to load

-q, --quiet
Produce less console output

-v, --verbose
Produce more console output

-l FILE, **--log-file** FILE
Log messages to the specified file

--package PACKAGE
The name of the package to import; if omitted this will be derived from the file(s) specified

--package-version VERSION
: The version of the package to import; if omitted this will be derived from the file(s) specified

--abi ABI
: The ABI of the package to import; if omitted this will be derived from the file(s) specified

--duration DURATION
: The time taken to build the package (default: 0s)

--output FILE
: The filename containing the build output to insert into the database; if this is omitted an appropriate message will be inserted instead

-y, --yes
: Run non-interactively; never prompt during operation

-d, --delete
: Remove the specified file(s) after a successful import; if the import fails, no files will be removed

--import-queue ADDR
: The address of the queue used by **piw-import** (default: (ipc:///tmp/piw-import); this should always be an ipc address

7.3 Usage

This utility is used to import wheels manually into the system. This is useful with packages which have no source available on PyPI, or binary-only packages from third parties. If invoked with multiple files, all files will be associated with a single "build" and the build will be for the package and version of the first file specified. No checks are made for equality of package name or version (as several packages on PyPI would violate such a rule!).

The utility can be run in a batch mode with *--yes* (page 16) but still requires invoking once per build required (you cannot register multiple builds in a single invocation).

The return code will be 0 if the build was registered and all files were uploaded successfully. Additionally the *--delete* (page 16) option can be specified to remove the source files once all uploads are completed successfully. If anything fails, the return code will be non-zero and no files will be deleted.

The utility should only ever be run directly on the master node (opening the import queue to other machines is a potential security risk).

CHAPTER 8

piw-rebuild

The piw-rebuild script is used to inject rebuild requests for various web pages into the piwheels system. This script must be run on the same node as the piw-master script.

8.1 Synopsis

```
piw-rebuild [-h] [--version] [-c FILE] [-q] [-v] [-l FILE] [-y]
            [--import-queue ADDR]
            part [package]
```

8.2 Description

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

--version
Show program's version number and exit

-c FILE, **--configuration** FILE
Specify a configuration file to load

-q, --quiet
Produce less console output

-v, --verbose
Produce more console output

-l FILE, **--log-file** FILE
Log messages to the specified file

-y, --yes
Run non-interactively; never prompt during operation

--import-queue ADDR
The address of the queue used by **piw-rebuild** (default: (ipc:///tmp/piw-import); this should always be an ipc address

8.3 Usage

This utility is used to request rebuilds of parts of the piwheels website. This is primarily useful after manual fixes to the database, manipulation of the file-system, or after large-scale upgrades which require rebuilding many pages.

The mandatory *part* parameter can be one of the following values, which specify which part of the website to rebuild:

Part	Description
home	Rebuild the home-page (/index.html)
search	Rebuild the JSON search-index (/packages.json)
project	Rebuild the project-page for the specified package (/project/*package*/index.html)
index	Rebuild the simple-index *and* the project-page for the specified package (/simple/*package*/index.html *and* /project/*package*/index.html)

If *part* is "project" or "index" you may optionally specify a *package* name for which to rebuild the specified part. If the *package* name is omitted, the utility will request a rebuild of the specified part for **all** known packages in the system.

Warning: In the case a rebuild of **all** packages is requested, you will be prompted to make sure you wish to continue (this option can take hours to process on a system with many builds). The `--yes` (page 17) option can be used to skip this prompt but should be used carefully!

Note that the utility only requests the rebuild of the specified part. This request will be queued, and acted upon as soon as *The Scribe* (page 26) reaches it but there is no guarantee this has occurred by the time the utility exits. The return code will be 0 if the rebuild request was queued successfully. If anything fails the return code will be non-zero and the request may or may not have been queued.

The utility should only ever be run directly on the master node (opening the import queue to other machines is a potential security risk).

CHAPTER 9

piw-remove

The piw-remove script is used to manually remove a version of a package from the system. All builds for the specified version will be forgotten, and all files generated by such builds will be deleted.

By default, the version removed will be deleted entirely (*not* marked to skip). Optionally, you can provide a skip reason; in this case the version will not be deleted (though its builds and files will), but will be left marked to skip to prevent future rebuilds.

9.1 Synopsis

```
piw-remove [-h] [--version] [-c FILE] [-q] [-v] [-l FILE] [-y]
           [-s REASON] [--import-queue ADDR]
           package version
```

9.2 Description

package
: The name of the package to remove

version
: The version of the package to remove

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

--version
: Show program's version number and exit

-c FILE, **--configuration** FILE
: Specify a configuration file to load

-q, --quiet
: Produce less console output

-v, --verbose
: Produce more console output

-l FILE, **--log-file** FILE
: Log messages to the specified file

-y, **--yes**
: Run non-interactively; never prompt during operation

-s REASON, **--skip** REASON
: Leave the version in place, but marked with a reason to prevent future build attempts

--import-queue ADDR
: The address of the queue used by piw-remove (default: (ipc:///tmp/piw-import); this should always be an ipc address

9.3 Usage

This utility is typically used in response to a request from a package maintainer to remove a specific build from the system. Usually because the presence of a piwheels build is causing issues in and of itself.

Note: Older versions of piwheels didn't heed PyPI deletion messages. This is no longer the case and this utility is no longer required to manually remove deleted packages.

The utility can be run in a batch mode with *--yes* (page 20) but still requires invoking once per deletion required (you cannot remove multiple versions in a single invocation).

The return code will be 0 if the version was successfully removed. If anything fails, the return code will be non-zero and no files should be deleted (but this cannot be guaranteed in all circumstances).

The utility should only ever be run directly on the master node (opening the import queue to other machines is a potential security risk).

CHAPTER 10

piw-logger

The piw-logger script is intended for use as an Apache "piped log script" but can also be used to feed pre-existing Apache logs to the master by feeding logs to the script's stdin. This script must be run on the same node as the *piw-master* (page 3) script.

10.1 Synopsis

```
piw-logger [-h] [--version] [-c FILE] [-q] [-v] [-l FILE]
                [--format FORMAT] [--log-queue ADDR] [--drop]
                [files [files ...]]
```

10.2 Description

files
: The log file(s) to load into the master; if omitted or "-" then stdin will be read which is the default for piped log usage

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

--version
: Show program's version number and exit

-c FILE, **--configuration** FILE
: Specify a configuration file to load

-q, --quiet
: Produce less console output

-v, --verbose
: Produce more console output

-l FILE, **--log-file** FILE
: Log messages to the specified file

--format FORMAT
: The Apache log format that log lines will be expected to be in (default: combined); the short-cuts common, combined and common_vhost can be used in addition to Apache LogFormat strings

--log-queue ADDR
: The address of the queue used by piw-logger (default: (ipc:///tmp/piw-logger); this should always be an ipc address

--drop
: Drop log records if unable to send them to the master after a short timeout; this should generally be specified when **piw-logger** is used as a piped log[7] script

10.3 Usage

This utility is typically used to pipe logs from a web-server, such as Apache[8] into the piwheels database where they can be used for analysis, and to keep the stats on the homepage up to date. Apache provides a capability to pipe all logs to a given script which can be used directly with **piw-logger**.

A typical configuration under a Debian-like operating system might use the Apache CustomLog[9] directive as follows, within the Apache virtual host reponsible for serving files to `pip` clients:

```
ErrorLog ${APACHE_LOG_DIR}/ssl_error.log
CustomLog ${APACHE_LOG_DIR}/ssl_access.log combined
CustomLog "|/usr/local/bin/piw-logger --drop" combined
```

[7] http://httpd.apache.org/docs/current/logs.html#piped
[8] https://httpd.apache.org/
[9] http://httpd.apache.org/docs/current/mod/mod_log_config.html#customlog

CHAPTER 11

Development

The main GitHub repository for the project can be found at:

https://github.com/piwheels/piwheels

After cloning, we recommend you set up a virtualenv for development and then execute `make develop` within that virtualenv. This should install all requirements for executing all tools, building the documentation and executing the test suite.

11.1 Testing

Executing the test suite requires that you have a local PostgreSQL[10] installation configured with an unprivileged user, a privileged super user, and a test database.

The test suite uses environment variables to discover the name of the test database, and the aforementioned users. See the top of `tests/conftest.py` for more details. A typical execution of the test suite might look as follows:

```
$ export PIWHEELS_TESTDB=piwtest
$ export PIWHEELS_USER=piwheels
$ export PIWHEELS_PASS=piwheels
$ export PIWHEELS_SUPERUSER=piwsuper
$ export PIWHEELS_SUPERPASS=foobar
$ cd piwheels
$ make test
```

You may wish to construct a script for exporting the environment variables, or add these values to your `~/.bashrc`.

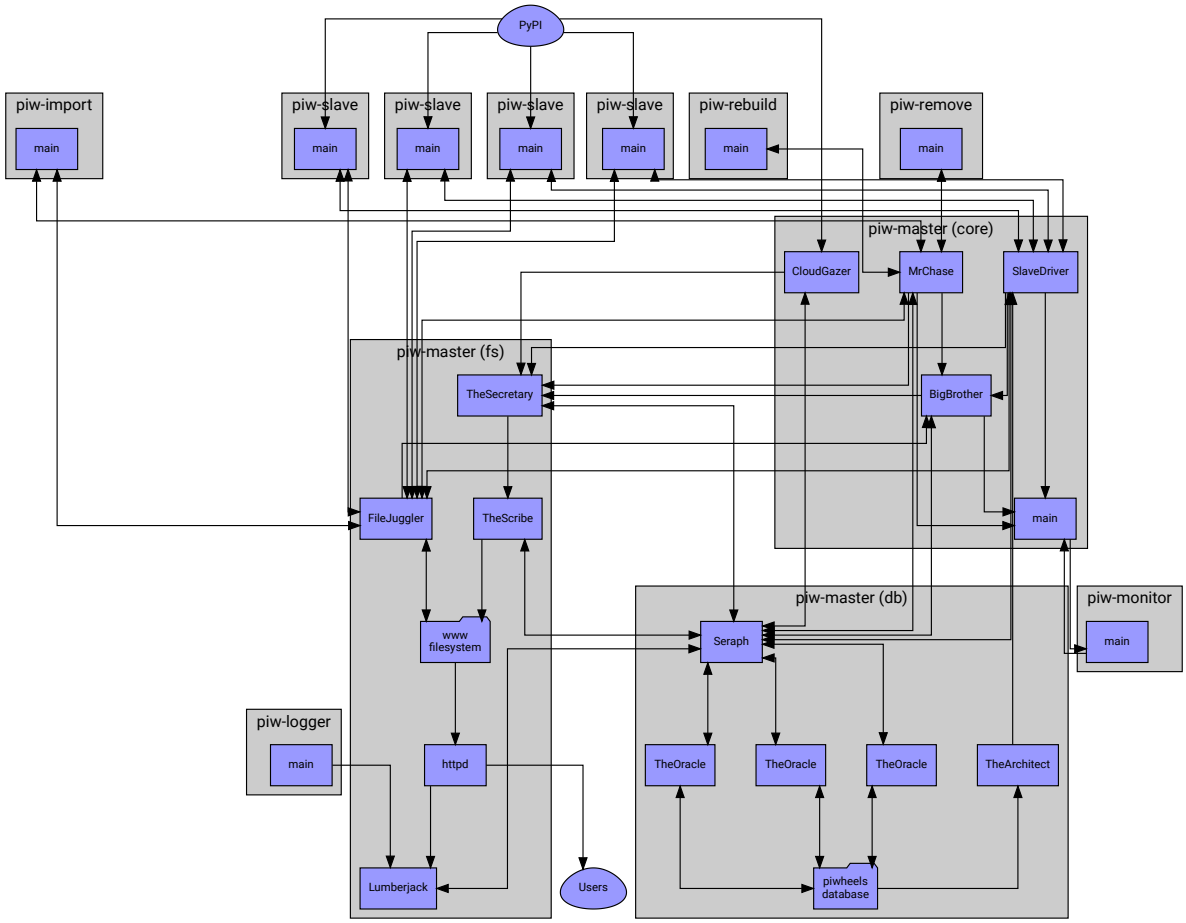
Note: If you are not using your local PostgreSQL installation for anything else you may wish to set `fsync=off` and `synchronous_commit=off` in your local `postgresql.conf` to speed up execution of the test suite. Do *NOT* do this on any production PostgreSQL server!

[10] https://postgresql.org/

11.2 Design

Although the piwheels master appears to be a monolithic script, it's actually composed of numerous (often extremely simple) tasks. Each task runs its own thread and all communication between tasks takes place over ZeroMQ[11] sockets. This is also how communication occurs between the master and the *piw-slave* (page 7), and the *piw-monitor* (page 9).

The following diagram roughly illustrates all the tasks in the system (including those of the build slaves and the monitor), along with details of the type of ZeroMQ socket used to communicate between them:



It may be confusing that the file server and database server appear to be separate to the master in the diagram. This is deliberate as the system's architecture is such that certain tasks can be easily broken off into entirely separate processes (potentially on separate machines), if required in future (either for performance or security reasons).

11.3 Tasks

The following sections document the tasks shown above (listed from the "front" at PyPI to the "back" at Users):

11.3.1 Cloud Gazer

Implemented in: `piwheels.master.cloud_gazer.CloudGazer`.

This task is the "front" of the system. It follows PyPI's event log for new package and version registrations, and writes those entries to the database. It does this via *The Oracle* (page 25).

[11] https://zeromq.org/

11.3.2 The Oracle

Implemented in: *piwheels.master.the_oracle.TheOracle* (page 40).

This task is the main interface to the database. It accepts requests from other tasks ("register this new package", "log this build", "what files were built with this package", etc.) and executes them against the database. Because database requests are extremely variable in their execution time, there are actually several instances of the oracle which sit behind *Seraph* (page 25).

11.3.3 Seraph

Implemented in: *piwheels.master.seraph.Seraph* (page 44).

Seraph is a simple load-balancer for the various instances of *The Oracle* (page 25). This is the task that *actually* accepts database requests. It finds a free oracle and passes the request along, passing back the reply when it's finished.

11.3.4 The Architect

Implemented in: *piwheels.master.the_architect.TheArchitect* (page 44).

This task is the final database related task in the master script. Unlike *The Oracle* (page 25) it periodically queries the database for the packages that need building and passes this information along to the *Slave Driver* (page 25).

11.3.5 Slave Driver

Implemented in: *piwheels.master.slave_driver.SlaveDriver* (page 44).

This task is the main coordinator of the build slaves' activities. When a build slave first comes online it introduces itself to this task (with information including the ABI it can build for), and asks for a package to build. If there is a pending package matching the build slave's ABI, it will be told to build that package.

Periodically, *The Architect* (page 25) refreshes this task's list of packages that require building.

Eventually the build slave will communicate whether or not the build succeeded, along with information about the build (log output, files generated, etc.). This task writes this information to the database via *The Oracle* (page 25). If the build was successful, it informs the *File Juggler* (page 26) that it should expect a file transfer from the relevant build slave.

Finally, when all files from the build have been transferred, the Slave Driver informs the *The Scribe* (page 26) that the package's index and project page will need (re)writing. It also periodically informs *Big Brother* (page 26) of the size of the build queue.

11.3.6 Mr. Chase

Implemented in: `piwheels.master.mr_chase.MrChase`.

This task talks to **`piw-import`** and handles importing builds manually into the system. It is essentially a cut-down version of the *Slave Driver* (page 25) with a correspondingly simpler protocol. It is also the end-point for **`piw-rebuild`** and **`piw-remove`**.

This task writes information to the database via *The Oracle* (page 25). If the imported build was successful, it informs the *File Juggler* (page 26) that it should expect a file transfer from the importer.

Finally, when all files from the build have been transferred, it informs the *The Scribe* (page 26) that the package's index and project pages will need (re)writing.

11.3.7 File Juggler

Implemented in: *piwheels.master.file_juggler.FileJuggler* (page 47).

This task handles file transfers from the build slaves to the master. Files are transferred in multiple (relatively small) chunks and are verified with the hash reported by the build slave (retrieved from the database via *The Oracle* (page 25)).

11.3.8 Big Brother

Implemented in: *piwheels.master.big_brother.BigBrother* (page 48).

This task is a bit of a miscellaneous one. It sits around periodically generating statistics about the system as a whole (number of files, number of packages, number of successful builds, number of builds in the last hour, free disk space, etc.) and sends these off to the *The Scribe* (page 26).

11.3.9 The Scribe

Implemented in: `piwheels.master.the_scribe.TheScribe`.

This task generates the web output for piwheels. It generates the home-page with statistics from *Big Brother* (page 26), the overall package index, individual package file lists, and project pages with messages from *Slave Driver* (page 25).

11.3.10 The Secretary

Implemented in *piwheels.master.the_secretary.TheSecretary* (page 49).

This task sits in front of *The Scribe* (page 26) and attempts to mitigate many of the repeated requests that typically get sent to it. For example, project pages (which are relatively expensive to generate, in database terms), may need regenerating every time a file is registered against a package version.

This often happens in a burst when a new package version is released, resulting in several (redundant) requests to re-write the same page with minimally changed information. The secretary buffers up such requests, eliminating duplicates before finally passing them to *The Scribe* (page 26) for processing.

11.4 Queues

It should be noted that the diagram omits several queues for the sake of brevity. For instance, there is a simple PUSH/PULL control queue between the master's "main" task and each sub-task which is used to relay control messages like `PAUSE`, `RESUME`, and `QUIT`.

Most of the protocols used by the queues are (currently) undocumented with the exception of those between the build slaves and the *Slave Driver* (page 25) and *File Juggler* (page 26) tasks (documented in the *piw-slave* (page 7) chapter).

However, all protocols share a common basis: messages are lists of Python objects. The first element is always string containing the action. Further elements are parameters specific to the action. Messages are encoded with CBOR[12].

[12] https://cbor.io/

11.5 Protocols

The following sections document the protocols used between the build slaves and the three sub-tasks that they talk to in the *piw-master* (page 3). Each protocol operates over a separate queue. All messages in the piwheels system follow a similar structure of being a tuple containing:

- A short unicode string indicating what sort of message it is.
- Data. The structure of the data is linked to the type of the message, and validated on both transmission and reception (see `piwheels.protocols` for more information).

For example the message telling a build slave what package and version to build looks like this in Python syntax:

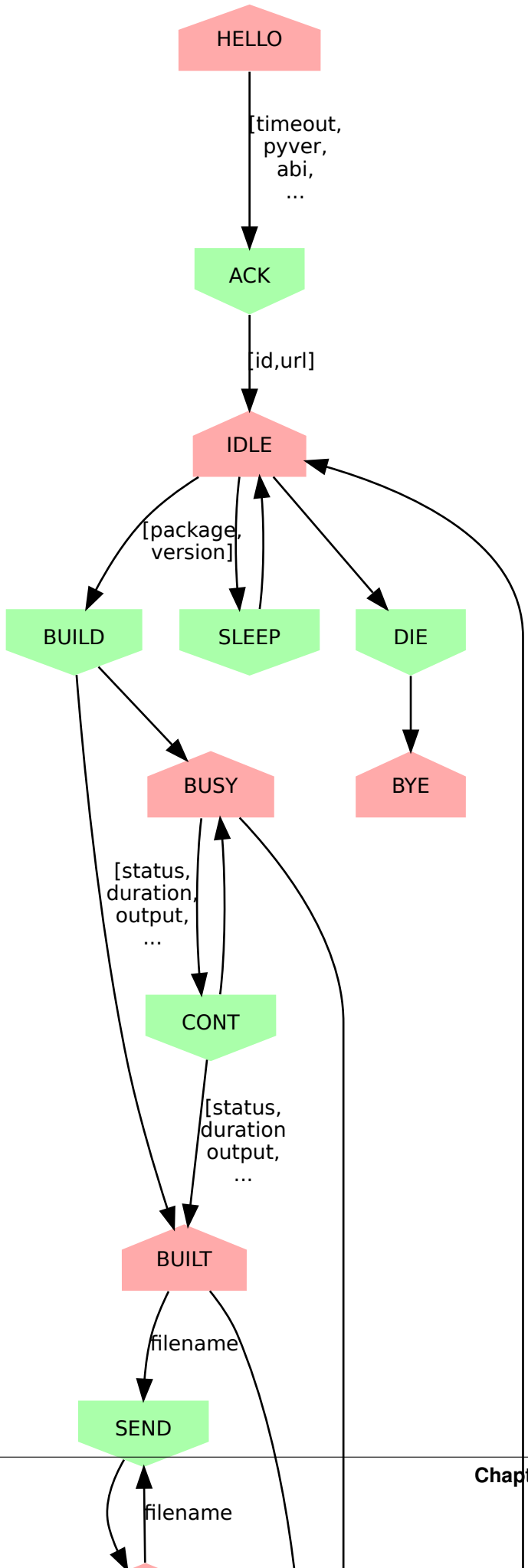
```
['BUILD', 'numpy', '1.14.0']
```

If a message is not associated with any data whatsoever, it is transmitted as a simple unicode string (without the list encapsulation). The serialization format for all messages in the system is currently CBOR[13].

11.5.1 Slave Driver

The queue that talks to *Slave Driver* (page 25) is a ZeroMQ REQ socket, hence the protocol follows a strict request-reply sequence which is illustrated below:

[13] https://cbor.io/


HELLO
[timeout,
pyver,
abi,
...
ACK
[id,url]
IDLE
[package,
version]
BUILD
SLEEP
DIE
BUSY
BYE
[status,
duration,
output,
...
CONT
[status,
duration
output,
...
BUILT
filename
SEND
filename

1. The new build slave sends "HELLO" with data `[build_timeout, master_timeout, py_version_tag, abi_tag, platform_tag, label, os_name, os_version, board_revision, board_serial]` where:
   - *build_timeout* is the slave's configured timeout (the length of time after which it will assume a build has failed and attempt to terminate it) as a `timedelta`[14].
   - *master_timeout* is the maximum length of time the slave will wait for communication from the master. After this timeout it will assume the connection has failed, terminate and clean-up any on-going build, then attempt to restart the connection to the master.
   - *py_version_tag* is the python version the slave will build for (e.g. "27", "35", etc.)
   - *abi_tag* is the ABI the slave will build for (e.g. "cp35m")
   - *platform_tag* is the platform of the slave (e.g. "linux_armv7l")
   - *label* is an identifying label for the slave (e.g. "slave2"); note that this label doesn't have to be anything specific, it's purely a convenience for administrators displayed in the monitor. In the current implementation this is the unqualified hostname of the slave
   - *os_name* is a string identifying the operating system, e.g. "Raspbian GNU/Linux".
   - *os_version* is a string identifying the release of the operating system, e.g. "10 (buster)".
   - *board_revision* is a code indicating the revision of the board that the slave is running upon, e.g. "c03111" for a Raspberry Pi 4B.
   - *board_serial* is the serial number of the board that the slave is running upon.
2. The master replies sends "ACK" with data `[slave_id, pypi_url]` where *slave_id* is an integer identifier for the slave. Strictly speaking, the build slave doesn't need this identifier but it can be helpful for admins or developers to see the same identifier in logs on the master and the slave which is the only reason it is communicated.

   The *pypi_url* is the URL the slave should use to fetch packages from PyPI.
3. The build slave sends "IDLE" to indicate that it is ready to accept a build job. The "IDLE" message is accompanied with the data `[now, disk_total, disk_free, mem_total, mem_free, load_avg, cpu_temp]` where:
   - *now* is a `datetime`[15] indicating the current time on the build slave.
   - *disk_total* is the total size (in bytes) of the file-system used to build wheels.
   - *disk_free* is the number of bytes free in the file-system used to build wheels.
   - *mem_total* is the total size (in bytes) of the RAM on the build slave.
   - *mem_free* is the number of bytes of RAM currently available (not necessarily unused, but potentially useable by builds).
   - *load_avg* is the one minute load average.
   - *cpu_temp* is the temperature, in degrees celsius of the CPU.
4. The master can reply with "SLEEP" which indicates that no jobs are currently available for that slave (e.g. the master is paused, or the build queue is empty, or there are no builds for the slave's particular ABI at this time). In this case the build slave should pause a while (the current implementation waits 10 seconds) before retrying "IDLE".
5. The master can also reply with "DIE" which indicates the build slave should shutdown. In this case, after cleaning up any resources the build slave should send back "BYE" and terminate (generally speaking, whenever the slave terminates it should send "BYE" no matter where in the protocol it occurs; the master will take this as a sign of termination).

[14] https://docs.python.org/3.5/library/datetime.html#datetime.timedelta
[15] https://docs.python.org/3.5/library/datetime.html#datetime.datetime

6. The master can also reply "BUILD" with data `[package, version]` where *package* is the name of a package to build and *version* is the version to build. At this point, the build slave should attempt to locate the package on PyPI and build a wheel from it.
7. While the build is underway, the slave must periodically ping the master with the "BUSY" message, which is accompanied by the exact same stats as in the "IDLE" message.
8. If the master wishes the build slave to continue with the build it will reply with "CONT". If the master wants to build slave to terminate the build early it will reply with "DONE" (goto step 13).
9. Assuming the master doesn't request termination of the build, eventually it will finish. In response to the next "CONT" message, the slave sends "BUILT" with data `[status, duration, output, files]`:
    - *status* is `True` if the build succeeded and `False` otherwise.
    - *duration* is a `timedelta`[16] value indicating the length of time it took to build in seconds.
    - *output* is a string containing the complete build log.
    - *files* is a `list`[17] of file state tuples containing the following fields in the specified order:
        - *filename* is the filename of the wheel.
        - *filesize* is the size in bytes of the wheel.
        - *filehash* is the SHA256 hash of the wheel contents.
        - *package_tag* is the package tag extracted from the filename.
        - *package_version_tag* is the version tag extracted from the filename.
        - *py_version_tag* is the python version tag extracted from the filename.
        - *abi_tag* is the ABI tag extracted from the filename (sanitized).
        - *platform_tag* is the platform tag extracted from the filename.
        - *dependencies* is a `set`[18] of dependency tuples containing the following fields in the specified order:
            * *tool* is the name of the tool used to install the dependency
            * *package* is the name of the package to install with the tool
10. If the build succeeded, the master will send "SEND" with data `filename` where *filename* is one of the names transmitted in the prior "BUILT" message.
11. At this point the slave should use the *File Juggler* (page 34) protocol documented below to transmit the contents of the specified file to the master. When the file transfer is complete, the build slave sends "SENT" to the master.
12. If the file transfer fails to verify, or if there are more files to send the master will repeat the "SEND" message. Otherwise, if all transfers have completed and have been verified, the master replies with "DONE".
13. The build slave is now free to destroy all resources associated with the build, and returns to step 3 ("IDLE").

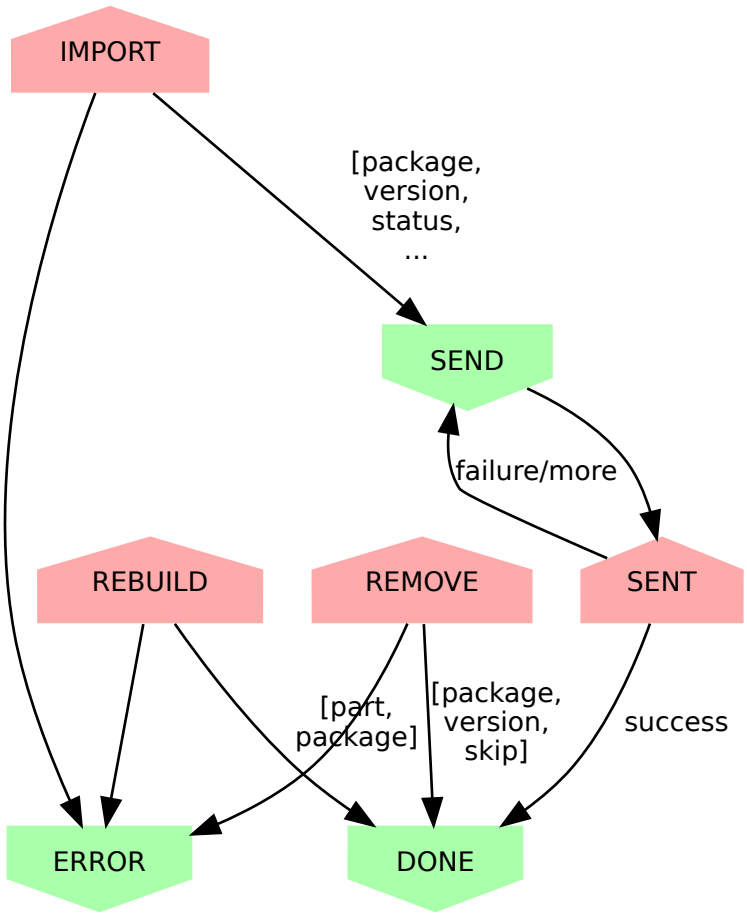
If at any point, the master takes longer than *master_timeout* (default: 5 minutes) to respond to a slave's request, the slave will assume the master has disappeared. If a build is still active, it will be cleaned up and terminated, the connection to the master will be closed, the slave's ID will be reset and the slave must restart the protocol from the top ("HELLO").

This permits the master to be upgraded or replaced without having to shutdown and restart the slaves manually. It is possible that the master is restarted too fast for the slave to notice. In this case the slave's next message will be mis-interpreted by the master as an invalid initial message, and it will be ignored. However, this is acceptable behaviour as the re-connection protocol described above will then effectively restart the slave after the *master_timeout* has elapsed.

[16] https://docs.python.org/3.5/library/datetime.html#datetime.timedelta
[17] https://docs.python.org/3.5/library/stdtypes.html#list
[18] https://docs.python.org/3.5/library/stdtypes.html#set

11.5.2 Mr Chase (importing)

The queue that talks to *Mr. Chase* (page 25) is a ZeroMQ REQ socket, hence the protocol follows a strict request-reply sequence which is illustrated below (see below for documentation of the "REMOVE" path):



1. The importer sends "IMPORT" with data `[slave_id, package, version, abi_tag, status, duration, output, files]`:
   - *slave_id* is the integer id of the build slave that created the wheel. This is usually 0 and is ignored by the master anyway.
   - *package* is the name of the package that the build is for.
   - *version* is the version of the package that the build is for.
   - *abi_tag* is either `None`, indicating that the master should use the "default" (minimum) build ABI registered in the system, or is a string indicating the ABI that the build was attempted for.
   - *status* is `True` if the build succeeded and `False` otherwise.
   - *duration* is a `float`[19] value indicating the length of time it took to build in seconds.
   - *output* is a string containing the complete build log.
   - *files* is a list of file state tuples containing the following fields in the specified order:
     - *filename* is the filename of the wheel.
     - *filesize* is the size in bytes of the wheel.
     - *filehash* is the SHA256 hash of the wheel contents.
     - *package_tag* is the package tag extracted from the filename.

[19] https://docs.python.org/3.5/library/functions.html#float

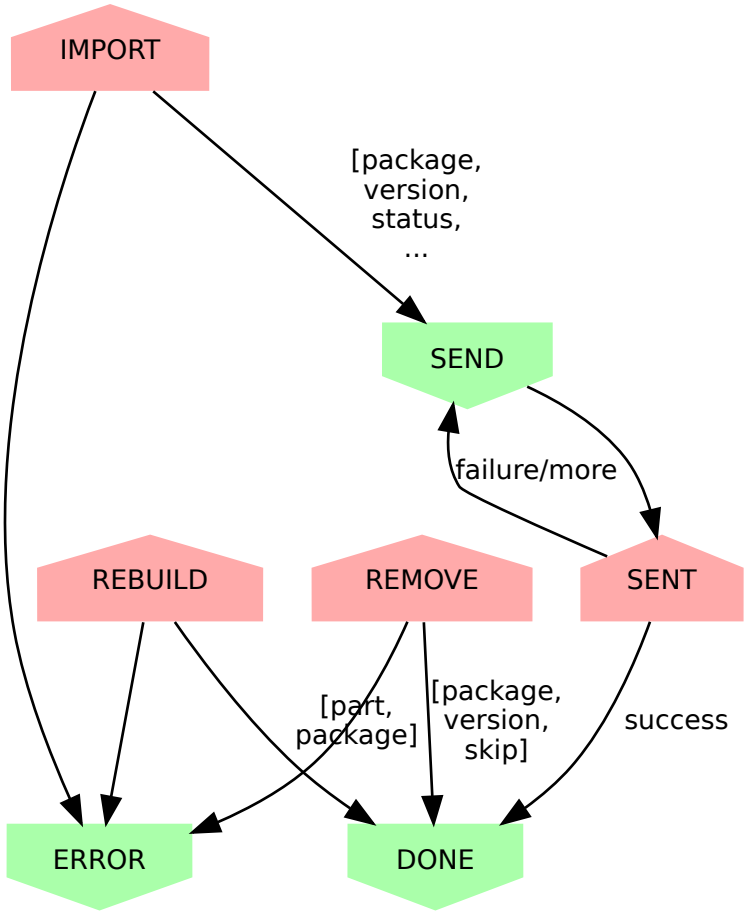
- *package_version_tag* is the version tag extracted from the filename.
- *py_version_tag* is the python version tag extracted from the filename.
- *abi_tag* is the ABI tag extracted from the filename (sanitized).
- *platform_tag* is the platform tag extracted from the filename.
- *dependencies* is a `set`[20] of dependency tuples containing the following fields in the specified order:
  - *tool* is the name of the tool used to install the dependency
  - *package* is the name of the package to install with the tool

2. If the import information is insufficient or incorrect, the master will send "ERROR" with data `message` which is the description of the error that occurred.
3. If the import information is okay, the master will send "SEND" with data `filename` for each file mentioned in the build.
4. At this point the importer should use the *File Juggler* (page 34) protocol to transmit the contents of the specified file to the master. When the file transfer is complete, the importer sends "SENT" to the master.
5. If the file transfer fails to verify, or if there are more files to send the master will repeat the "SEND" message. Otherwise, if all transfers have completed and have been verified, the master replies with "DONE".
6. The importer is now free to remove all files associated with the build, if requested to.

11.5.3 Mr Chase (removing)

The queue that talks to *Mr. Chase* (page 25) is a ZeroMQ REQ socket, hence the protocol follows a strict request-reply sequence which is illustrated below (see above for documentation of the `IMPORT` path):

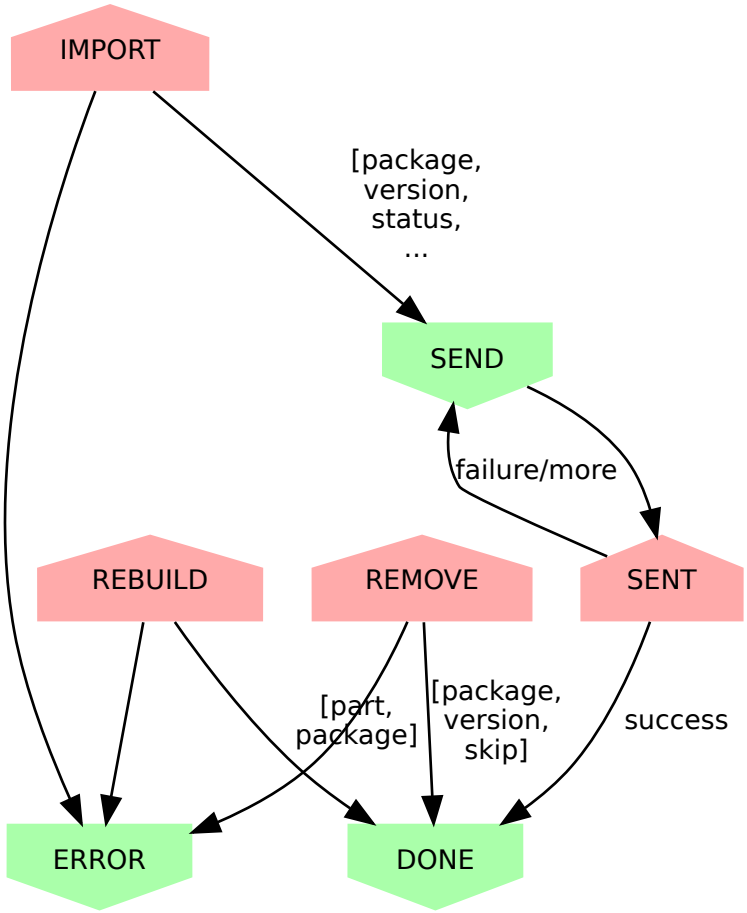
[20] https://docs.python.org/3.5/library/stdtypes.html#set



1. The utility sends "REMOVE" with data `[package, version, skip]`:
   - *package* is the name of the package to remove.
   - *version* is the version of the package to remove.
   - *skip* is a string containing the reason the version should never be built again, or is a blank string indicating the version should be rebuilt.
2. If the removal fails (e.g. if the package or version does not exist), the master will send "ERROR" with data `message` (a string describing the error that occurred).
3. If the removal is successful, the master replies with "DONE".

11.5.4 Mr Chase (rebuilding)

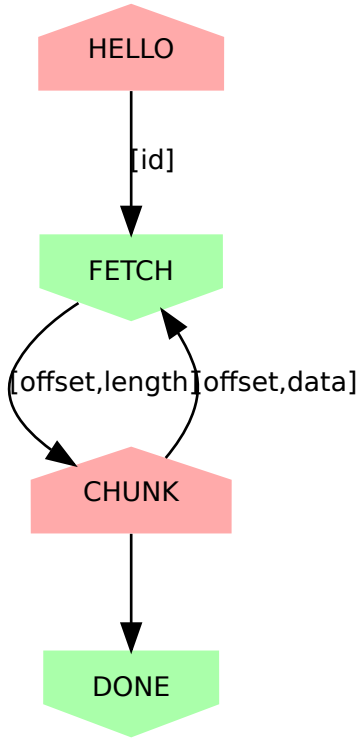
The queue that talks to *Mr. Chase* (page 25) is a ZeroMQ REQ socket, hence the protocol follows a strict request-reply sequence which is illustrated below (see above for documentation of the `IMPORT` path):



1. The utility sends "REBUILD" with data `[part, package]`:
   - *part* is the part of the website to rebuild. It must be one of "HOME", "SEARCH", "PROJECT" or "BOTH".
   - *package* is the name of the package to rebuild indexes and/or project pages for or `None` if pages for all packages should be rebuilt. This parameter is omitted if *part* is "HOME" or "SEARCH".
2. If the rebuild request fails (e.g. if the package does not exist), the master will send "ERROR" with data `message` (a string describing the error that occurred).
3. If the rebuild request is successful, the master replies with "DONE".

11.5.5 File Juggler

The queue that talks to *File Juggler* (page 26) is a ZeroMQ DEALER socket. This is because the protocol is semi-asynchronous (for performance reasons). For the sake of illustration, a synchronous version of the protocol is illustrated below:



1. The build slave initially sends "HELLO" with data `slave_id` where *slave_id* is the integer identifier of the slave. The master knows what file it requested from this slave (with "SEND" to the Slave Driver), and knows the file hash it is expecting from the "BUILT" message.
2. The master replies with "FETCH" with data `[offset, length]` where *offset* is a byte offset into the file, and *length* is the number of bytes to send.
3. The build slave replies with "CHUNK" with `data` where *data* is a byte-string containing the requested bytes from the file.
4. The master now either replies with another "FETCH" message or, when it has all chunks successfully received, replies with "DONE" indicating the build slave can now close the file (though it can't delete it yet; see the "DONE" message on the Slave Driver side for that).

"FETCH" messages may be repeated if the master drops packets (due to an overloaded queue). Furthermore, because the protocol is semi-asynchronous multiple "FETCH" messages will be sent before the master waits for any returning "CHUNK" messages.

11.6 Security

Care must be taken when running the build slave. Building all packages in PyPI effectively invites the denizens of the Internet to run arbitrary code on your machine. For this reason, the following steps are recommended:

1. Never run the build slave on the master; ensure they are entirely separate machines.
2. Run the build slave as an unprivileged user which has access to nothing it doesn't absolutely require (it shouldn't have any access to the master's file-system, the master's database, etc.)
3. Install the build slave's code in a location the build slave's unprivileged user does not have write access (i.e. *not* in a virtualenv under the user's home dir).
4. Consider whether to make the unprivileged user's home-directory read-only.

We have experimented with read-only home directories, but a significant portion of (usually scientifically oriented) packages attempt to be "friendly" and either write data to the user's home directory or modify the user's profile (`~/.bashrc` and so forth).

The quandry is whether it is better to fail with such packages (a read-only home-directory will most likely crash such setup scripts, failing the build), or partially support them (leaving the home-directory writeable even though the modifications on the build-slave won't be recorded in the resulting wheel and thus won't be replicated on user's machines). There is probably no universally good answer.

Currently, while the build slave cleans up the temporary directory used by pip during wheel building, it doesn't attempt to clean its own home directory (which setup scripts are free to write to). This is something that ought to be addressed in future as it's a potentially exploitable hole.

CHAPTER 12

Module Reference

This chapter contains all the documentation auto-generated from the source code. It is probably not terribly useful for reading through, but may be useful as a searchable reference.

- *piwheels.master* (page 38)
- *piwheels.master.db* (page 38)
- *piwheels.master.cloud_gazer* (page 40)
- *piwheels.master.the_oracle* (page 40)
- *piwheels.master.seraph* (page 44)
- *piwheels.master.the_architect* (page 44)
- *piwheels.master.slave_driver* (page 44)
- *piwheels.master.mr_chase* (page 47)
- *piwheels.master.file_juggler* (page 47)
- *piwheels.master.big_brother* (page 48)
- *piwheels.master.the_secretary* (page 49)
- *piwheels.master.the_scribe* (page 49)
- *piwheels.slave* (page 49)
- *piwheels.slave.builder* (page 49)
- *piwheels.initdb* (page 49)
- *piwheels.importer* (page 50)
- *piwheels.remove* (page 50)
- *piwheels.transport* (page 50)
- *piwheels.tasks* (page 52)
- *piwheels.states* (page 54)
- *piwheels.ranges* (page 59)

12.1 piwheels.master

12.2 piwheels.master.db

This module defines the low level database API, *Database* (page 38). This is a simple core SQLAlchemy affair which runs trivial queries against the PostgreSQL database. All the serious logic is defined within views in the database itself.

class piwheels.master.db.**Database**(*dsn*)
PiWheels database connection class

add_new_package(*package*, *skip=''*, *description=''*)
Insert a new package record into the database. Returns True if the row was inserted successfully, or False if a key violation occurred.

add_new_package_version(*package*, *version*, *released=None*, *skip=''*)
Insert a new package version record into the database. Returns True if the row was inserted successfully, or False if a key violation occurred.

delete_build(*package*, *version*)
Remove all builds for the specified package and version, along with all files records.

delete_package(*package*)
Remove the specified package, along with all builds and files.

delete_version(*package*, *version*)
Remove the specified version of the specified package, along with all builds and files.

get_all_package_versions()
Returns the set of all known (package, version) tuples.

get_all_packages()
Returns the set of all known package names.

get_build_abis()
Return the set of ABIs that the master should attempt to build.

get_build_queue(*limit=1000*)
Returns a mapping of ABI tags to an ordered list of up to *limit* package version tuples which currently need building for that ABI.

get_file_apt_dependencies(*filename*)
Returns a set of the apt dependencies for the specified *filename*.

get_package_description(*package*)
Retrieve the description for *package* in the packages table.

get_package_files(*package*)
Returns a mapping of filenames to file hashes; this is all the data required to build the simple index.html for the specified package.

get_project_files(*package*)
Returns all details required to build the files table in the project page of the specified *package*.

get_project_versions(*package*)
Returns all details required to build the versions table in the project page of the specified *package*.

get_pypi_serial()
Return the serial number of the last PyPI event.

get_search_index()
Return a mapping of all packages to their download count for the last month. This is used to construct the searchable package index.

get_statistics()
Return various build related statistics from the database.

get_version_files(*package*, *version*)
Returns the names of all files for *version* of *package*.

get_version_skip(*package*, *version*)
Returns the reason for skipping *version* of *package*.

get_versions_deleted(*package*)
Return any versions of *package* which have been marked for deletion.

load_rewrites_pending()
Loads the rewrites-pending queue (the internal state of `TheSecretary`) from the database.

log_build(*build*)
Log a build attempt in the database, including build output and wheel info if successful.

log_download(*download*)
Log a download in the database, including data derived from JSON in pip's user-agent.

log_json(*json*)
Log a project's JSON page hit in the database.

log_page(*page*)
Log a web page hit in the database.

log_project(*project*)
Log a project page hit in the database.

log_search(*search*)
Log a search in the database, including data derived from JSON in pip's user-agent.

package_marked_deleted(*package*)
Check whether *package* has been marked for deletion.

save_rewrites_pending(*queue*)
Save the rewrites-pending queue (the internal state of `TheSecretary`) in the database. The *queue* parameter is expected to be a list of `RewritePendingRow` tuples.

set_package_description(*package*, *description*)
Update the description for *package* in the packages table.

set_pypi_serial(*serial*)
Update the serial number of the last PyPI event.

skip_package(*package*, *reason*)
Mark a package with a reason to prevent future builds of all versions (and all future versions).

skip_package_version(*package*, *version*, *reason*)
Mark a version of a package with a reason to prevent future build attempts.

test_package(*package*)
Check whether *package* already exists in the database. Returns a boolean.

test_package_version(*package*, *version*)
Check whether *version* of *package* already exists in the database. Returns a boolean.

unyank_version(*package*, *version*)
Mark the specified version of the specified package version as "unyanked".

yank_version(*package*, *version*)
Mark the specified version of the specified package version as "yanked".

12.3 piwheels.master.cloud_gazer

12.4 piwheels.master.the_oracle

Defines *TheOracle* (page 40) task and the *DbClient* (page 42) RPC class for talking to it.

class piwheels.master.the_oracle.**TheOracle**(*config*)

This task provides an RPC-like interface to the database; it handles requests such as registering a new package, version, or build, and answering queries about the hashes of files. The primary clients of this class are *SlaveDriver* (page 44), TheScribe, and CloudGazer.

Note that because database requests are notoriously variable in length the client RPC class (*DbClient* (page 42)) doesn't *directly* talk to *TheOracle* (page 40). Rather, multiple instances of *TheOracle* (page 40) are spawned and *Seraph* (page 44) sits in front of these acting as a simple load-sharing router for the RPC clients.

close()

Close all registered queues. This should be overridden to close any additional queues the task holds which aren't registered.

do_allpkgs()

Handler for "ALLPKGS" message, sent by *DbClient* (page 42) to request the set of all packages define known to the database.

do_allvers()

Handler for "ALLVERS" message, sent by *DbClient* (page 42) to request the set of all (package, version) tuples known to the database.

do_delbuild(*package*, *version*)

Handler for "DELBUILD" message, sent by *DbClient* (page 42) to remove all builds (and files and downloads by cascade) for *version* of *package*.

do_delpkg(*package*)

Handler for "DELPKG" message, sent by *DbClient* (page 42) to delete a package.

do_delver(*package*, *version*)

Handler for "DELVER" message, sent by *DbClient* (page 42) to delete a specific version of a package.

do_filedeps(*filename*)

Handler for "FILEDEPS" message, sent by *DbClient* (page 42) to request apt dependencies for *filename*, returned as a set of dependencies excluding those which are preinstalled in the distro version with the corresponding ABI tag.

do_getabis()

Handler for "GETABIS" message, sent by *DbClient* (page 42) to request the list of all ABIs to build for.

do_getdesc(*package*)

Handler for "GETDESC" message, sent by *DbClient* (page 42) to retrieve a package's project description.

do_getpypi()

Handler for "GETPYPI" message, sent by *DbClient* (page 42) to request the record of the last serial number from the PyPI changelog.

do_getsearch()

Handler for "GETSEARCH" message, sent by *DbClient* (page 42) to request the recent download statistics, returned as a mapping of package to (downloads_recent, downloads_all) tuples.

do_getskip(*package*, *version*)

Handler for "GETSKIP" message, send by *DbClient* (page 42) to request the reason for skipping builds of *version* of *package*.

do_getstats()
Handler for "GETSTATS" message, sent by *DbClient* (page 42) to request the latest database statistics, returned as a list of (field, value) tuples.

do_loadrwp()
Handler for "LOADRWP" message, sent by *DbClient* (page 42) to request the content of the `rewrites_pending` table.

do_logbuild(*build*)
Handler for "LOGBUILD" message, sent by *DbClient* (page 42) to register a new build result.

do_logdownload(*download*)
Handler for "LOGDOWNLOAD" message, sent by *DbClient* (page 42) to register a new download.

do_logjson(*json*)
Handler for "LOGJSON" message, sent by *DbClient* (page 42) to register a new project JSON download.

do_logpage(*page*)
Handler for "LOGPAGE" message, sent by *DbClient* (page 42) to register a new web page hit.

do_logproject(*project*)
Handler for "LOGPROJECT" message, sent by *DbClient* (page 42) to register a new project page hit.

do_logsearch(*search*)
Handler for "LOGSEARCH" message, sent by *DbClient* (page 42) to register a new search.

do_newpkg(*package*, *skip*, *description*)
Handler for "NEWPKG" message, sent by *DbClient* (page 42) to register a new package.

do_newver(*package*, *version*, *released*, *skip*)
Handler for "NEWVER" message, sent by *DbClient* (page 42) to register a new (package, version) tuple.

do_pkgdeleted(*package*)
Handler for "PKGDELETED" message, sent by *DbClient* (page 42) to request whether or not the specified *package* has been marked for deletion.

do_pkgexists(*package*)
Handler for "PKGEXISTS" message, sent by *DbClient* (page 42) to request whether or not the specified *package* exists.

do_pkgfiles(*package*)
Handler for "PKGFILES" message, sent by *DbClient* (page 42) to request details of all wheels assocated with *package*.

do_projfiles(*package*)
Handler for "PROJFILES" message, sent by *DbClient* (page 42) to request file details of all versions of *package*.

do_projvers(*package*)
Handler for "PROJVERS" message, sent by *DbClient* (page 42) to request build and skip details of all versions of *package*.

do_saverwp(*queue*)
Handler for "SAVERWP" message, sent by *DbClient* (page 42) to request that *queue* is saved to the `rewrites_pending` table.

do_setdesc(*package*, *description*)
Handler for "SETDESC" message, sent by *DbClient* (page 42) to update a package's project description.

do_setpypi(*serial*)
Handler for "SETPYPI" message, sent by *DbClient* (page 42) to update the last seen serial number from the PyPI changelog.

do_skippkg(*package*, *reason*)
Handler for "SKIPPKG" message, sent by *DbClient* (page 42) to skip building all versions of a package.

do_skipver(*package*, *version*, *reason*)
Handler for "SKIPVER" message, sent by *DbClient* (page 42) to skip building a specific version of a package.

do_unyankver(*package*, *version*)
Handler for "UNYANKVER" message, sent by *DbClient* (page 42) to mark a specific version of a package as not "yanked".

do_verexists(*package*, *version*)
Handler for "VEREXISTS" message, sent by *DbClient* (page 42) to request whether or not the specified *version* of *package* exists.

do_verfiles(*package*, *version*)
Handler for "VERFILES" message, sent by *DbClient* (page 42) to request the filenames of all wheels associated with *version* of *package*.

do_versdeleted(*package*)
Handler for "VERSDELETED" message, sent by *DbClient* (page 42) to request any versions for *package* which have been marked for deletion.

do_yankver(*package*, *version*)
Handler for "YANKVER" message, sent by *DbClient* (page 42) to mark a specific version of a package as "yanked".

handle_db_request(*queue*)
Handle incoming requests from *DbClient* (page 42) instances.

class piwheels.master.the_oracle.**DbClient**(*config*, *logger=None*)
RPC client class for talking to *TheOracle* (page 40).

add_new_package(*package*, *skip=''*, *description=''*)
See *db.Database.add_new_package()* (page 38).

add_new_package_version(*package*, *version*, *released=None*, *skip=''*)
See *db.Database.add_new_package_version()* (page 38).

delete_build(*package*, *version*)
See *db.Database.delete_build()* (page 38).

delete_package(*package*)
See *db.Database.delete_package()* (page 38).

delete_version(*package*, *version*)
See *db.Database.delete_version()* (page 38).

get_all_package_versions()
See *db.Database.get_all_package_versions()* (page 38).

get_all_packages()
See *db.Database.get_all_packages()* (page 38).

get_build_abis()
See *db.Database.get_build_abis()* (page 38).

get_file_apt_dependencies(*filename*)
See *db.Database.get_file_apt_dependencies()* (page 38).

get_package_description(*package*)
See db.Database.get_project_description().

get_package_files(*package*)
See *db.Database.get_package_files()* (page 38).

get_project_files(*package*)
See *db.Database.get_project_files()* (page 38).

get_project_versions(*package*)
See *db.Database.get_project_versions()* (page 38).

get_pypi_serial()
See *db.Database.get_pypi_serial()* (page 38).

get_search_index()
See *db.Database.get_search_index()* (page 38).

get_statistics()
See *db.Database.get_statistics()* (page 38).

get_version_files(*package*, *version*)
See *db.Database.get_version_files()* (page 38).

get_version_skip(*package*, *version*)
See *db.Database.get_version_skip()* (page 39).

get_versions_deleted(*package*)
See *db.Database.get_versions_deleted()* (page 39).

load_rewrites_pending()
See *db.Database.load_rewrites_pending()* (page 39).

log_build(*build*)
See *db.Database.log_build()* (page 39).

log_download(*download*)
See *db.Database.log_download()* (page 39).

log_json(*json*)
See *db.Database.log_json()* (page 39).

log_page(*page*)
See *db.Database.log_page()* (page 39).

log_project(*project*)
See *db.Database.log_project()* (page 39).

log_search(*search*)
See *db.Database.log_search()* (page 39).

package_marked_deleted(*package*)
See *db.Database.package_marked_deleted()* (page 39).

save_rewrites_pending(*queue*)
See *db.Database.save_rewrites_pending()* (page 39).

set_package_description(*package*, *description*)
See db.Database.update_project_description().

set_pypi_serial(*serial*)
See *db.Database.set_pypi_serial()* (page 39).

skip_package(*package*, *reason*)
See *db.Database.skip_package()* (page 39).

skip_package_version(*package*, *version*, *reason*)
See *db.Database.skip_package_version()* (page 39).

test_package(*package*)
See *db.Database.test_package()* (page 39).

test_package_version(*package*, *version*)
See *db.Database.test_package_version()* (page 39).

unyank_version(*package*, *version*)
See *db.Database.unyank_version()* (page 39).

yank_version(*package*, *version*)
See *db.Database.yank_version()* (page 39).

12.5 piwheels.master.seraph

Defines the *Seraph* (page 44) task; see class for more details.

class piwheels.master.seraph.**Seraph**(*config*)
This task is a simple load-sharing router for *TheOracle* (page 40) tasks.

handle_back(*queue*)
Receive a response from an instance of *TheOracle* (page 40) on the back queue. Strip off the worker's address frame and add it back to the available queue then send the response back to the client that made the original request.

handle_front(*queue*)
If any workers are currently available, receive *DbClient* (page 42) requests from the front queue and send it on to the worker including the client's address frame.

12.6 piwheels.master.the_architect

Defines *TheArchitect* (page 44) task; see class for more details.

class piwheels.master.the_architect.**TheArchitect**(*config*)
This task queries the backend database to determine which versions of packages have yet to be built (and aren't marked to be skipped). It pushes the results to *SlaveDriver* (page 44) to sort out.

close()
Close all registered queues. This should be overridden to close any additional queues the task holds which aren't registered.

quit()
Overridden to cancel any existing long-running query.

update_build_queue()
The architect simply runs the build queue query repeatedly, with a break of a minute between each execution.

All entries found within this limit are sorted into per-ABI queues and pushed to *SlaveDriver* (page 44) which queues and dispatches jobs to build ABI-matched slaves as they become available.

12.7 piwheels.master.slave_driver

Defines the *SlaveDriver* (page 44) task; see class for more details.

class piwheels.master.slave_driver.**SlaveDriver**(*config*)
This task handles interaction with the build slaves using the slave protocol. Interaction is driven by the slaves (i.e. the master doesn't *push* jobs, rather the slaves *request* a job and the master replies with the next (package, version) tuple from the internal "builds" queue).

The task also incidentally interacts with several other queues: the internal "status" queue is sent details of every reply sent to a build slave (the `main_loop()` method passes this information on to any listening monitors). Also, the internal "indexes" queue is informed of any packages that need web page indexes re-building (as a result of a successful build).

close()
Close all registered queues. This should be overridden to close any additional queues the task holds which aren't registered.

do_built(*slave*)
Handler for the build slave's "BUILT" message, which is sent after an attempted package build succeeds or fails. The handler logs the result in the database and, if files have been generated by the build, informs the *FileJuggler* (page 47) task to expect a file transfer before sending "SEND" back to the build slave with the required filename.

If no files were generated (e.g. in the case of a failed build, or a degenerate success), "DONE" is returned indicating that the build slave is free to discard all resources generated during the build and return to its idle state.

do_busy(*slave*)
Handler for the build slave's "BUSY" message, which is sent periodically during package builds. If the slave fails to respond with a BUSY ping for a duration longer than `SlaveState.busy_timeout` then the master will assume the slave has died and remove it from the internal state mapping (if the slave happens to resurrect itself later the master will simply treat it as a new build slave).

In response to "BUSY" the master can respond "CONT" to indicate the build should continue processing, or "DONE" to indicate that the build slave should immediately terminate and discard the build and return to "IDLE" state.

do_bye(*slave*)
Handler for the build slave's final "BYE" message upon shutdown. This removes the associated state from the internal `slaves` dict.

Parameters **slave** (`SlaveState` (page 55)) – The object representing the current status of the build slave.

do_hello(*slave*)
Handler for the build slave's initial "HELLO" message. This associates the specified *slave* state with the slave's address and returns "HELLO" with the master's id for the slave (the id communicated back simply for consistency of logging; administrators can correlate master log messages with slave log messages when both have the same id number; we can't use IP address for this as multiple slaves can run on one machine).

Parameters **slave** (`SlaveState` (page 55)) – The object representing the current status of the build slave.

do_idle(*slave*)
Handler for the build slave's "IDLE" message (which is effectively the slave requesting work). If the master wants to terminate the slave, it sends back "BYE". If the build queue (for the slave's ABI) is empty or the task is currently paused, "SLEEP" is returned indicating the slave should wait a while and then try again.

If a job can be retrieved from the (ABI specific) build queue, then a "BUILD" message is sent back with the required package and version.

Parameters **slave** (`SlaveState` (page 55)) – The object representing the current status of the build slave.

do_sent(*slave*)
Handler for the build slave's "SENT" message indicating that it's finished sending the requested file to `FileJuggler`. The `FsClient` RPC mechanism is used to ask `FileJuggler` to verify the transfer against the stored hash and, if this is successful, a message is sent to `TheScribe` to regenerate the package's index.

If further files remain to be transferred, another "SEND" message is returned to the build slave. Otherwise, "DONE" is sent to free all build resources.

If a transfer fails to verify, another "SEND" message with the same filename is returned to the build slave.

handle_build(*queue*)
Refresh the ABI-specific queues of package versions waiting to be built. The queues are limited to 1000 packages per ABI, and are kept as lists ordered by release date. When a message arrives from `TheArchitect` it refreshes (replaces) all current queues. There is, however, still a duplication possibility as `TheArchitect` doesn't know what packages are actively being built; this method handles filtering out such packages.

Even if the active builds fail (because build slaves crash, or the network dies) this doesn't matter as a future re-run of the build queue query will return these packages again, and if no build slaves are actively working on them at that time they will then be retried.

handle_control(*queue*)
Handle incoming requests to the internal control queue.

This class understands a couple of extra control messages unique to it, specifically "KILL" to tell a build slave to terminate, "SKIP" to tell a build slave to terminate its current build immmediately, and "HELLO" to cause all "HELLO" messages from build slaves to be replayed (for the benefit of a newly attached monitor process).

handle_delete(*queue*)
Handle package or version deletion requests.

When the PyPI upstream deletes a version or package, the `CloudGazer` task requests that other tasks perform the deletion on its behalf. In the case of this task, this involves cancelling any pending builds of that package (version), and ignoring any builds involving that package (version) in the next queue update from `TheArchitect`.

handle_slave(*queue*)
Handle requests from build slaves.

See the *piw-slave* (page 7) chapter for an overview of the protocol for messages between build slaves and *SlaveDriver* (page 44). This method retrieves the message from the build slave, finds the associated *SlaveState* (page 55) and updates it with the message, then calls the appropriate message handler. The handler will be expected to return a reply (in the usual form of a list of strings) or `None` if no reply should be sent (e.g. for a final "BYE" message).

kill_slave(*slave_id*)
Additional task control method to trigger a "KILL" message to the internal control queue. See *handle_control()* (page 46) for more information.

list_slaves()
Additional task control method to trigger a "HELLO" message to the internal control queue. See *quit()* (page 53) for more information.

remove_expired()
Remove slaves which have exceeded their timeout.

skip_slave(*slave_id*)
Additional task control method to trigger a "SKIP" message to the internal control queue. See *handle_control()* (page 46) for more information.

sleep_slave(*slave_id*)
Additional task control method to trigger a "SLEEP" message to the internal control queue. See *handle_control()* (page 46) for more information.

wake_slave(*slave_id*)
Additional task control method to trigger a "WAKE" message to the internal control queue. See *handle_control()* (page 46) for more information.

12.8 piwheels.master.mr_chase

12.9 piwheels.master.file_juggler

Defines the *FileJuggler* (page 47) task and the *FsClient* (page 48) RPC class for interacting with it.

exception piwheels.master.file_juggler.**TransferError**
Base class for errors raised during a file transfer.

exception piwheels.master.file_juggler.**TransferIgnoreChunk**
Exception raised when a build slave sends CHUNK instead of HELLO as the first message (see *FileJuggler.new_transfer()* (page 48)).

exception piwheels.master.file_juggler.**TransferDone**
Exception raised when a transfer is complete. It may seem a little odd to use an exception for this, but it is "exceptional" behaviour to terminate the file transfer.

class piwheels.master.file_juggler.**FileJuggler**(*config*)
This task handles file transfers from the build slaves. The specifics of the file transfer protocol are best understood from the implementation of the *FileState* (page 54) class.

However, to detail how a file transfer begins: when a build slave has successfully completed a build it informs the master via the *SlaveDriver* (page 44) task. That task replies with a "SEND" instruction to the slave (including a filename). The slave then initiates the transfer with a "HELLO" message to this task. Once transfers are complete the slave sends a "SENT" message to the *SlaveDriver* (page 44) task which verifies the transfer and either retries it (when verification fails) or sends back "DONE" indicating the slave can wipe the source file.

current_transfer(*transfer*, *msg*, **args*)
Called for messages associated with an existing file transfer.

Usually this is "CHUNK" indicating another chunk of data. Rarely, it can be "HELLO" if the master has fallen silent and dropped tons of packets.

Parameters

- **transfer** (*TransferState* (page 56)) – The object representing the state of the transfer.
- **msg** (*str*[21]) – The message sent during the transfer.
- ***args** – All additional arguments; for "CHUNK" the first must be the file offset and the second the data to write to that offset.

do_expect(*slave_id*, *file_state*)
Message sent by *FsClient* (page 48) to inform file juggler that a build slave is about to start a file transfer. The message includes the full *FileState* (page 54). The state is stored in the `pending` map.

Parameters

- **slave_id** (*int*[22]) – The identity of the build slave about to begin the transfer.
- **file_state** (*list*[23]) – The details of the file to be transferred including the expected hash.

do_verify(*slave_id*, *package*)
Message sent by *FsClient* (page 48) to request that juggler verify a file transfer against the expected hash and, if it matches, rename the file into its final location.

Parameters

[21] https://docs.python.org/3.5/library/stdtypes.html#str
[22] https://docs.python.org/3.5/library/functions.html#int
[23] https://docs.python.org/3.5/library/stdtypes.html#list

- **slave_id** (*int*[24]) – The identity of the build slave that sent the file.
- **package** (*str*[25]) – The name of the package that the file is to be committed to, if valid.

handle_file(*queue*)
Handle incoming file-transfer messages from build slaves.

The file transfer protocol is in some ways very simple (see the chart in the *piw-slave* (page 7) chapter for an overview of the message sequence) and in some ways rather complex (read the ZeroMQ guide chapter on file transfers for more detail on why multiple messages must be allowed in flight simultaneously).

The "normal" state for a file transfer is to be requesting and receiving chunks. Anything else, including redundant re-sends, and transfer completion is handled as an exceptional case.

handle_fs_request(*queue*)
Handle incoming messages from *FsClient* (page 48) instances.

new_transfer(*msg*, **args*)
Called for messages initiating a new file transfer.

The first message must be HELLO along with the id of the slave starting the transfer. The metadata for the transfer will be looked up in the `pending` list (which is written to by *do_expect()* (page 47)).

Parameters

- **msg** (*str*[26]) – The message sent to start the transfer (must be "HELLO")
- ***args** – All additional arguments (expected to be an integer slave id).

once()
This method is called once before the task loop starts. It the task needs to do some initialization or setup within the task thread, this is the place to do it.

class piwheels.master.file_juggler.**FsClient**(*config*, *logger=None*)
RPC client class for talking to *FileJuggler* (page 47).

expect(*slave_id*, *file_state*)
See *FileJuggler.do_expect()* (page 47).

verify(*slave_id*, *package*)
See *FileJuggler.do_verify()* (page 47).

12.10 piwheels.master.big_brother

Defines the *BigBrother* (page 48) task; see class for more details.

class piwheels.master.big_brother.**BigBrother**(*config*)
This task periodically queries the database and output file-system for various statistics like the number of packages known to the system, the number built, the number of packages built in the last hour, the remaining file-system space, etc. These statistics are written to the internal "status" queue which `main_loop()` uses to pass statistics to any listening monitors.

close()
Close all registered queues. This should be overridden to close any additional queues the task holds which aren't registered.

handle_control(*queue*)
Handle incoming requests to the internal control queue.

This just adds handling for the custom STATS verb to replay the master stats history.

[24] https://docs.python.org/3.5/library/functions.html#int
[25] https://docs.python.org/3.5/library/stdtypes.html#str
[26] https://docs.python.org/3.5/library/stdtypes.html#str

12.11 piwheels.master.the_secretary

Defines the *TheSecretary* (page 49) task; see class for more details.

class piwheels.master.the_secretary.**TheSecretary**(*config*)

This task buffers requests for the scribe, for the purpose of consolidating multiple consecutive (duplicate) requests.

Requests to write the project page for a package (which is a relatively expensive operation in terms of database accesses) can come in thick and fast, particularly when a new version is being registered with lots of files. There's little point in writing the project page 5 times in as many seconds, or writing the project page, then the index and project page immediately afterward. This class is used to buffer requests for up to a minute, allowing us to eliminate many of the duplicate requests.

close()

Close all registered queues. This should be overridden to close any additional queues the task holds which aren't registered.

handle_input(*queue*)

Handle incoming write requests with buffering and de-dupe.

Some incoming requests (currently "HOME", "SEARCH", "DELPKG", and "DELVER") are passed directly through to `TheScribe` as these are either sufficiently rare ("HOME", "SEARCH") that no benefit is gained by buffering them or sufficiently urgent ("DELPKG", "DELVER") that they must be acted on immediately.

For other requests ("PROJECT" and "BOTH"), requests can come thick and fast in the case of multiple file registrations picked up by `CloudGazer`. In this case, requests are buffered for a minute and de-duplicated; e.g. if several requests are made to re-write the project page for package "foo" within that period, they will be combined into a single request. After the minute of buffering, the request is passed down to `TheScribe`.

handle_output()

Passes buffered requests downstream.

This sub-task runs periodically to pluck things from the internal buffer that have reached the minute delay, and passes them downstream to `TheScribe`. The process stops when we run out of things that have expired.

once()

This method is called once before the task loop starts. It the task needs to do some initialization or setup within the task thread, this is the place to do it.

12.12 piwheels.master.the_scribe

12.13 piwheels.slave

12.14 piwheels.slave.builder

12.15 piwheels.initdb

Contains the functions that make up the **piw-initdb** script.

piwheels.initdb.**main**(*args=None*)

This is the main function for the **piw-initdb** script. It creates the piwheels database required by the master or, if it already exists, upgrades it to the current version of the application.

piwheels.initdb.**detect_users**(*conn*, *test_user*)
Test that the user for *conn* is a cluster superuser (so we can drop and create anything we want in the database), and that *test_user* (which will be granted limited rights to various objects for the purposes of the **piw-master** script) exists and is *not* a cluster superuser.

piwheels.initdb.**detect_version**(*conn*)
Detect the version of the database. This is typically done by reading the contents of the `configuration` table, but before that was added we can guess a couple of versions based on what tables exist (or don't). Returns `None` if the database appears uninitialized, and raises `RuntimeError`[27] is the version is so ancient we can't do anything with it.

piwheels.initdb.**get_connection**(*dsn*)
Return an SQLAlchemy connection to the specified *dsn* or raise `RuntimeError`[28] if the database doesn't exist (the administrator is expected to create the database before running this script).

piwheels.initdb.**get_script**(*version=None*)
Generate the script to get the database from *version* (the result of *detect_version()* (page 50)) to the current version of the software. If *version* is `None`, this is simply the contents of the `sql/create_piwheels.sql` script. Otherwise, it is a concatenation of various update scripts.

piwheels.initdb.**parse_statements**(*script*)
This is an extremely crude statement splitter for PostgreSQL's dialect of SQL. It understands `--comments`, `"quoted identifiers"`, `'string literals'` and `$delim$ extended strings $delim$`, but not `E'\escaped strings'` or `/* C-style comments */`. If you start using such things in the update scripts, you'll need to extend this function to accommodate them.

It returns a generator which yields individiual statements from *script*, delimited by semi-colon terminators.

12.16 piwheels.importer

12.17 piwheels.remove

Contains the functions that implement the **piw-remove** script.

piwheels.remove.**main**(*args=None*)
This is the main function for the **piw-remove** script. It uses `MrChase` to remove built packages from the system.

piwheels.remove.**do_remove**(*config*)
Handles constructing and sending the "REMOVE" message to `master.mr_chase.MrChase`.

Parameters **config** – The configuration obtained from parsing the command line.

12.18 piwheels.transport

This module augments the classes provided by pyzmq (the 0MQ Python bindings) to use CBOR encoding, and voluptuous for message validation. It also tweaks a few minor things like using seconds for timeouts.

class piwheels.transport.**Context**
Wrapper for 0MQ `zmq.Context`. This extends the `socket()` method to include parameters for the socket's protocol and logger.

class piwheels.transport.**Socket**(*socket*, *protocol=None*, *logger=None*)
Wrapper for `zmq.Socket`. This extends 0MQ's sockets to include a protocol which will be used to validate messages that are sent and received (via a voluptuous schema), and a logger which can be used to debug socket behaviour.

[27] https://docs.python.org/3.5/library/exceptions.html#RuntimeError
[28] https://docs.python.org/3.5/library/exceptions.html#RuntimeError

bind(*address*)
Binds the socket to listen on the specified *address*.

close(*linger=None*)
Closes the socket. If *linger* is specified, it is the number of seconds to wait for pending messages to be flushed.

connect(*address*)
Connects the socket to the listening socket at *address*.

drain()
Receives all pending messages in the queue and discards them. This is typically useful during shutdown routines or for testing.

poll(*timeout=None*, *flags=<MagicMock name='mock.POLLIN' id='139706694284680'>*)
Polls the socket for pending data (by default, when *flags* is POLLIN). If no data is available after *timeout* seconds, returns False. Otherwise returns True.

If *flags* is POLLOUT instead, tests whether the socket has available slots for queueing new messages.

recv(*flags=0*)
Receives the next message as a `bytes`[29] string.

recv_addr_msg(*flags=0*)
Receive a CBOR-encoded message (and associated data) along with the address it came from (represented as a `bytes`[30] string).

recv_msg(*flags=0*)
Receive a CBOR-encoded message, returning a tuple of the unicode message string and its associated data. This is the primary method used in piwheels for receving information into a task.

The message, and its associated data, will be validated agains the `protocol` associated with the socket on construction.

recv_multipart(*flags=0*)
Receives a multi-part message, returning its content as a list of `bytes`[31] strings.

send(*buf*, *flags=0*)
Send *buf* (a `bytes`[32] string).

send_addr_msg(*addr*, *msg*, *data=NoData*, *flags=0*)
Send a CBOR-encoded message (and associated data) to *addr*, a `bytes`[33] string.

send_msg(*msg*, *data=NoData*, *flags=0*)
Send the unicode string *msg* with its associated *data* as a CBOR-encoded message. This is the primary method used in piwheels for sending information between tasks.

The message, and its associated data, must validate against the `protocol` associated with the socket on construction.

send_multipart(*msg_parts*, *flags=0*)
Send *msg_parts*, a list of `bytes`[34] strings as a multi-part message which can be received intact with *`recv_multipart()`* (page 51).

subscribe(*topic*)
Subscribes SUB type sockets to the specified *topic* (a string prefix).

unsubscribe(*topic*)
Unsubscribes SUB type sockets from the specified *topic* (a string prefix).

[29] https://docs.python.org/3.5/library/functions.html#bytes
[30] https://docs.python.org/3.5/library/functions.html#bytes
[31] https://docs.python.org/3.5/library/functions.html#bytes
[32] https://docs.python.org/3.5/library/functions.html#bytes
[33] https://docs.python.org/3.5/library/functions.html#bytes
[34] https://docs.python.org/3.5/library/functions.html#bytes

hwm
The high-water mark of the socket, i.e. the number of messages that can be queued before the socket blocks (or drops, depending on the socket type) messages.

class piwheels.transport.**Poller**
Wrapper for 0MQ `zmq.Poller`. This simply tweaks 0MQ's poller to use seconds for timeouts, and to return a `dict`[35] by default from *poll()* (page 52).

poll(*timeout=None*)
Poll all registered sockets for the events they were registered with, for *timeout* seconds. Returns a dictionary mapping sockets to events or an empty dictinoary if the *timeout* elapsed with no events occurring.

register(*sock*, *flags=<MagicMock name='mock.POLLIN.__or__()' id='139706694292648'>*)
Register *sock* with the poller, watching for events as specified by *flags* (which defaults to POLLIN and POLLOUT events).

unregister(*sock*)
Unregister *sock* from the poller. After this, calls to *poll()* (page 52) will never return references to *sock*.

12.19 piwheels.tasks

Implements the base classes (*Task* (page 52) and its derivative *PauseableTask* (page 53)) which form the basis of all the tasks in the piwheels master.

exception piwheels.tasks.**TaskQuit**
Exception raised when the "QUIT" message is received by the internal control queue.

class piwheels.tasks.**Task**(*config*, *control_protocol=Protocol(recv={'PAUSE': NoData, 'RESUME': NoData, 'QUIT': NoData}, send={})*)
The *Task* (page 52) class is a `Thread`[36] derivative which is the base for all tasks in the piwheels master. The *run()* (page 53) method is overridden to perform a simple task loop which calls *poll()* (page 53) once a cycle to react to any messages arriving into queues, and to dispatch any periodically executed methods.

Queues are associated with handlers via the *register()* (page 53) method. Periodic methods are associated with an interval via the *every()* (page 52) method. These should be called during initialization (don't attempt to register handlers from within the thread itself).

Generally this shouldn't be used as a base-class. Use one of the descendents that implements a pausing mechanism, `NonStopTask`, *PauseableTask* (page 53), or `PausingTask`.

close()
Close all registered queues. This should be overridden to close any additional queues the task holds which aren't registered.

every(*interval*, *handler*)
Register *handler* to be called every *interval* periodically.

Parameters

- **interval** (*timedelta*) – The time interval between each run of *handler*.
- **handler** – The function or method to call periodically.

force(*handler*)
Force *handler* to run next time its interval is polled.

handle_control(*queue*)
Default handler for the internal control queue. In this base class it simply handles the "QUIT" message

[35] https://docs.python.org/3.5/library/stdtypes.html#dict
[36] https://docs.python.org/3.5/library/threading.html#threading.Thread

by raising *TaskQuit* (page 52) (which the *run()* (page 53) method will catch and use as a signal to end).

Messages other than QUIT, PAUSE and RESUME raise `TaskControl` which can be caught in descendents to implement custom control messages.

once()
This method is called once before the task loop starts. It the task needs to do some initialization or setup within the task thread, this is the place to do it.

pause()
Requests that the task pause itself. This is an idempotent method; it's always safe to call repeatedly and even if the task isn't pauseable it'll simply be ignored.

poll(*timeout=1*)
This method is called once per loop of the task's *run()* (page 53) method. It runs all periodic handlers, then polls all registered queues and calls their associated handlers if the poll is successful.

quit()
Requests that the task terminate at its earliest convenience. To wait until the task has actually closed, call `join()` afterwards.

register(*queue*, *handler*, *flags=<MagicMock name='mock.POLLIN' id='139706694284680'>*)
Register *queue* to be polled on each cycle of the task. Any messages with the relevant *flags* (defaults to `POLLIN`) will trigger the specified *handler* method which is expected to take a single argument which will be *queue*.

Parameters

- **queue** (`transport.Socket` (page 50)) – The queue to poll.
- **handler** – The function or method to call when a message with matching *flags* arrives in *queue*.
- **flags** (*int*[37]) – The flags to match in the queue poller (defaults to `POLLIN`).

resume()
Requests that the task resume itself. This is an idempotent method; it's safe to call repeatedly and even if the task isn't pauseable it'll simply be ignored.

run()
This method is the main task loop. Override this to perform one-off startup processing within the task's background thread, and to perform any finalization required.

socket(*sock_type*, *protocol=None*)
Construct a socket and link it to the logger for this task. This is primarily useful for debugging purposes, but also ensures that the task will implicitly close and clean up the socket when it closes.

class piwheels.tasks.**PauseableTask**(*config*, *control_protocol=Protocol(recv={'PAUSE': NoData, 'RESUME': NoData, 'QUIT': NoData}, send={})*)
Derivative of *Task* (page 52) that implements a rudimentary pausing mechanism. When the "PAUSE" message is received on the internal control queue, the task will enter a loop which simply polls the control queue waiting for "RESUME" or "QUIT". No other work will be done (`Task.loop()` and *Task.poll()* (page 53) will not be called) until the task is resumed (or terminated).

If you need a more complex pausing implementation which can still do some work while paused (to drain incoming queues for instance), use `PausingTask` instead.

handle_control(*queue*)
Default handler for the internal control queue. In this base class it simply handles the "QUIT" message by raising *TaskQuit* (page 52) (which the `run()` method will catch and use as a signal to end).

Messages other than QUIT, PAUSE and RESUME raise `TaskControl` which can be caught in descendents to implement custom control messages.

[37] https://docs.python.org/3.5/library/functions.html#int

12.20 piwheels.states

This module defines several classes which permit interested tasks to track the state of build slaves (*SlaveState* (page 55)), file transfers (*TransferState* (page 56)), build attempts (*BuildState* (page 54)), build artifacts (*FileState* (page 54)) and various loggers.

class piwheels.states.**FileState**(*filename*, *filesize*, *filehash*, *package_tag*, *package_version_tag*, *py_version_tag*, *abi_tag*, *platform_tag*, *dependencies*, *transferred=False*)

Represents the state of an individual build artifact (a package file, or wheel) including its `filename`, `filesize`, the SHA256 `filehash`, and various tags extracted from the build. Also tracks whether or not the file has been `transferred`.

Parameters

- **filename** (*str*[38]) – The original filename of the build artifact.
- **filesize** (*int*[39]) – The size of the file in bytes.
- **filehash** (*str*[40]) – The SHA256 hash of the file contents.
- **package_tag** (*str*[41]) – The package tag extracted from the filename (first "-" separated component).
- **package_version_tag** (*str*[42]) – The package version tag extracted from the filename (second "-" separated component).
- **py_version_tag** (*str*[43]) – The python version tag extracted from the filename (third from last "-" separated component).
- **abi_tag** (*str*[44]) – The python ABI tag extracted from the filename (second from last "-" separated component).
- **platform_tag** (*str*[45]) – The platform tag extracted from the filename (last "-" separated component).
- **dependencies** (*set*[46]) – The set of dependencies that are required to use this particular wheel.
- **transferred** (*bool*[47]) – `True` if the file has been transferred from the build slave that generated it to the file server.

as_message()

Convert the *FileState* (page 54) object into a simpler list for serialization and transport.

classmethod from_message(*value*)

Convert the output from *as_message()* (page 54) back into a *BuildState* (page 54).

verified()

Called to set `transferred` to `True` after a file transfer has been successfully verified.

class piwheels.states.**BuildState**(*slave_id*, *package*, *version*, *abi_tag*, *status*, *duration*, *output*, *files*, *build_id=None*)

Represents the state of a package build including the `package`, `version`, `status`, build `duration`, and all the lines of `output`. The *files* (page 55) attribute is a mapping containing details of each successfully built package file.

[38] https://docs.python.org/3.5/library/stdtypes.html#str
[39] https://docs.python.org/3.5/library/functions.html#int
[40] https://docs.python.org/3.5/library/stdtypes.html#str
[41] https://docs.python.org/3.5/library/stdtypes.html#str
[42] https://docs.python.org/3.5/library/stdtypes.html#str
[43] https://docs.python.org/3.5/library/stdtypes.html#str
[44] https://docs.python.org/3.5/library/stdtypes.html#str
[45] https://docs.python.org/3.5/library/stdtypes.html#str
[46] https://docs.python.org/3.5/library/stdtypes.html#set
[47] https://docs.python.org/3.5/library/functions.html#bool

Parameters

- **slave_id** (*int*[48]) – The master's identifier for the build slave.
- **package** (*str*[49]) – The name of the package to build.
- **version** (*str*[50]) – The version number of the package to build.
- **abi_tag** (*str*[51]) – The ABI for which the build was attempted (must not be `'none'`).
- **status** (*bool*[52]) – `True` if the build succeeded, `False` if it failed.
- **duration** (*timedelta*) – The amount of time (in seconds) it took to complete the build.
- **output** (*str*[53]) – The log output of the build.
- **files** (*dict*[54]) – A mapping of filenames to *FileState* (page 54) objects for each artifact produced by the build.
- **build_id** (*int*[55]) – The integer identifier generated for the build by the database (`None` until the build has been inserted into the database).

as_message()
Convert the *BuildState* (page 54), and its nested *FileState* (page 54) objects into simpler lists for serialization and transport.

classmethod from_message(*value*)
Convert the output from *as_message()* (page 55) back into a *BuildState* (page 54).

logged(*build_id*)
Called to fill in the build's ID in the backend database.

files
A mapping of filename to *FileState* (page 54) instances.

next_file
Returns the filename of the next file that needs transferring or `None` if all files have been transferred.

transfers_done
Returns `True` if all files have been transferred.

class piwheels.states.**SlaveState**(*address*, *build_timeout*, *busy_timeout*, *native_py_version*, *native_abi*, *native_platform*, *label*, *os_name*, *os_version*, *board_revision*, *board_serial*)
Tracks the state of a build slave. The master updates this state with each request and reply sent to and received from the slave, and this class in turn manages the associated *BuildState* (page 54) (accessible from `build`) and *TransferState* (page 56) (accessible from `transfer`). The class also tracks the time a request was last seen from the build slave, and includes a `kill()` method.

Parameters

- **address** (*bytes*[56]) – The slave's ephemeral 0MQ address.

> **Note:** This is *not* the slave's IP address; it's a unique identifier generated on connection to the master's ROUTER socket. It will be different each time the slave re-connects (due to timeout, reboot, etc).

[48] https://docs.python.org/3.5/library/functions.html#int
[49] https://docs.python.org/3.5/library/stdtypes.html#str
[50] https://docs.python.org/3.5/library/stdtypes.html#str
[51] https://docs.python.org/3.5/library/stdtypes.html#str
[52] https://docs.python.org/3.5/library/functions.html#bool
[53] https://docs.python.org/3.5/library/stdtypes.html#str
[54] https://docs.python.org/3.5/library/stdtypes.html#dict
[55] https://docs.python.org/3.5/library/functions.html#int
[56] https://docs.python.org/3.5/library/functions.html#bytes

- **timeout** (*int*[57]) – The number of seconds after which any build will be considered to have timed out (and the slave will be assumed crashed).
- **native_py_version** (*str*[58]) – The slave's native Python version.
- **native_abi** (*str*[59]) – The slave's native Python ABI.
- **native_platform** (*str*[60]) – The slave's native platform.
- **label** (*str*[61]) – A label representing the slave.

class piwheels.states.**TransferState**(*slave_id*, *file_state*)

Tracks the state of a file transfer. All file transfers are held in temporary locations until `verify()` indicates the transfer was successful, at which point they are atomically renamed into their final location.

The state is intimately tied to the file transfer protocol and includes methods to write a recevied `chunk()`, and to determine the next chunk to `fetch()`, as well as a property to determine when the transfer is `done`.

Parameters

- **slave_id** (*str*[62]) – The ID number of the slave which built the file.
- **file_state** (`FileState` (page 54)) – The details of the file to be transferred (filename, size, hash, etc.)

class piwheels.states.**DownloadState**

Represents the state of the log entry for a download of a package wheel file, including its `filename`, the user's `host` IP, access `timestamp` and information about the operating system and installer.

Parameters

- **filename** (*str*[63]) – The filename of the downloaded wheel file.
- **host** – The hostname or IP address of the user.
- **timestamp** (*datetime.datetime*[64]) – The timestamp at which the file was downloaded.
- **or None arch** (*str*[65]) – The architecture of the user's computer system (usually armv6 or armv7).
- **distro_name** (*str*[66] *or None*[67]) – The user's operating system distribution name (e.g. Raspbian).
- **distro_version** (*str*[68] *or None*[69]) – The version of the user's operating system distribution.
- **os_name** (*str*[70] *or None*[71]) – The name of the user's operating system (e.g. Linux).
- **os_version** (*str*[72] *or None*[73]) – The version of the user's operating system (e.g. Linux kernel version).

[57] https://docs.python.org/3.5/library/functions.html#int
[58] https://docs.python.org/3.5/library/stdtypes.html#str
[59] https://docs.python.org/3.5/library/stdtypes.html#str
[60] https://docs.python.org/3.5/library/stdtypes.html#str
[61] https://docs.python.org/3.5/library/stdtypes.html#str
[62] https://docs.python.org/3.5/library/stdtypes.html#str
[63] https://docs.python.org/3.5/library/stdtypes.html#str
[64] https://docs.python.org/3.5/library/datetime.html#datetime.datetime
[65] https://docs.python.org/3.5/library/stdtypes.html#str
[66] https://docs.python.org/3.5/library/stdtypes.html#str
[67] https://docs.python.org/3.5/library/constants.html#None
[68] https://docs.python.org/3.5/library/stdtypes.html#str
[69] https://docs.python.org/3.5/library/constants.html#None
[70] https://docs.python.org/3.5/library/stdtypes.html#str
[71] https://docs.python.org/3.5/library/constants.html#None
[72] https://docs.python.org/3.5/library/stdtypes.html#str
[73] https://docs.python.org/3.5/library/constants.html#None

- **py_name** (*str*[74] *or None*[75]) – The Python implementation used (e.g. CPython).
- **py_version** (*str*[76] *or None*[77]) – The Python version used (e.g. 3.7.3).
- **installer_name** (*str*[78] *or None*[79]) – The name of the tool used to install the file (e.g. pip).
- **installer_version** (*str*[80] *or None*[81]) – The version of the tool (e.g. pip) used to install the file.
- **setuptools_version** (*str*[82] *or None*[83]) – The version of setuptools used.

class piwheels.states.**SearchState**

Represents the state of the log entry for an instance of a package search, including the `package` name, user's `host` IP, access `timestamp` and information about the operating system and installer.

Parameters

- **package** (*str*[84]) – The name of the package searched for.
- **host** (*str*[85]) – The hostname or IP address of the user.
- **timestamp** (*datetime.datetime*[86]) – The timestamp at which the search occurred.
- **arch** (*str*[87] *or None*[88]) – The architecture of the user's computer system (usually armv6 or armv7).
- **distro_name** (*str*[89] *or None*[90]) – The user's operating system distribution name (e.g. Raspbian).
- **distro_version** (*str*[91] *or None*[92]) – The version of the user's operating system distribution.
- **os_name** (*str*[93] *or None*[94]) – The name of the user's operating system (e.g. Linux).
- **os_version** (*str*[95] *or None*[96]) – The version of the user's operating system (e.g. Linux kernel version).
- **py_name** (*str*[97] *or None*[98]) – The Python implementation used (e.g. CPython).
- **py_version** (*str*[99] *or None*[100]) – The Python version used (e.g. 3.7.3).

[74] https://docs.python.org/3.5/library/stdtypes.html#str
[75] https://docs.python.org/3.5/library/constants.html#None
[76] https://docs.python.org/3.5/library/stdtypes.html#str
[77] https://docs.python.org/3.5/library/constants.html#None
[78] https://docs.python.org/3.5/library/stdtypes.html#str
[79] https://docs.python.org/3.5/library/constants.html#None
[80] https://docs.python.org/3.5/library/stdtypes.html#str
[81] https://docs.python.org/3.5/library/constants.html#None
[82] https://docs.python.org/3.5/library/stdtypes.html#str
[83] https://docs.python.org/3.5/library/constants.html#None
[84] https://docs.python.org/3.5/library/stdtypes.html#str
[85] https://docs.python.org/3.5/library/stdtypes.html#str
[86] https://docs.python.org/3.5/library/datetime.html#datetime.datetime
[87] https://docs.python.org/3.5/library/stdtypes.html#str
[88] https://docs.python.org/3.5/library/constants.html#None
[89] https://docs.python.org/3.5/library/stdtypes.html#str
[90] https://docs.python.org/3.5/library/constants.html#None
[91] https://docs.python.org/3.5/library/stdtypes.html#str
[92] https://docs.python.org/3.5/library/constants.html#None
[93] https://docs.python.org/3.5/library/stdtypes.html#str
[94] https://docs.python.org/3.5/library/constants.html#None
[95] https://docs.python.org/3.5/library/stdtypes.html#str
[96] https://docs.python.org/3.5/library/constants.html#None
[97] https://docs.python.org/3.5/library/stdtypes.html#str
[98] https://docs.python.org/3.5/library/constants.html#None
[99] https://docs.python.org/3.5/library/stdtypes.html#str
[100] https://docs.python.org/3.5/library/constants.html#None

- **installer_name** (*str*[101] *or None*[102]) – The name of the tool used (e.g. pip).
- **installer_version** (*str*[103] *or None*[104]) – The version of the tool (e.g. pip) used.
- **setuptools_version** (*str*[105] *or None*[106]) – The version of setuptools used.

class piwheels.states.**ProjectState**

Represents the state of the log entry for an instance of project page hit, including the `page` name, the user's `host` IP, access `timestamp` and the user's `user_agent`.

Parameters

- **package** (*str*[107]) – The name of the package searched for.
- **host** (*str*[108]) – The hostname or IP address of the user.
- **timestamp** (*datetime.datetime*[109]) – The timestamp at which the page was accessed.
- **user_agent** (*str*[110]) – The user agent of the page request.

class piwheels.states.**JSONState**

Represents the state of the log entry for an instance of project JSON download, including the `page` name, the user's `host` IP, access `timestamp` and the user's `user_agent`.

Parameters

- **package** (*str*[111]) – The name of the package whose JSON file was accessed.
- **host** (*str*[112]) – The hostname or IP address of the user.
- **timestamp** (*datetime.datetime*[113]) – The timestamp at which the page was accessed.
- **user_agent** (*str*[114]) – The user agent of the request.

class piwheels.states.**PageState**

Represents the state of the log entry for an instance of web page hit, including the `page` name, the user's `host` IP, access `timestamp` and the user's `user_agent`.

Parameters

- **page** (*str*[115]) – The name of the page accessed.
- **host** (*str*[116]) – The IP address of the user.
- **timestamp** (*datetime.datetime*[117]) – The timestamp at which the page was accessed.
- **user_agent** (*str*[118]) – The user agent of the page request.

class piwheels.states.**SlaveStats**

[101] https://docs.python.org/3.5/library/stdtypes.html#str
[102] https://docs.python.org/3.5/library/constants.html#None
[103] https://docs.python.org/3.5/library/stdtypes.html#str
[104] https://docs.python.org/3.5/library/constants.html#None
[105] https://docs.python.org/3.5/library/stdtypes.html#str
[106] https://docs.python.org/3.5/library/constants.html#None
[107] https://docs.python.org/3.5/library/stdtypes.html#str
[108] https://docs.python.org/3.5/library/stdtypes.html#str
[109] https://docs.python.org/3.5/library/datetime.html#datetime.datetime
[110] https://docs.python.org/3.5/library/stdtypes.html#str
[111] https://docs.python.org/3.5/library/stdtypes.html#str
[112] https://docs.python.org/3.5/library/stdtypes.html#str
[113] https://docs.python.org/3.5/library/datetime.html#datetime.datetime
[114] https://docs.python.org/3.5/library/stdtypes.html#str
[115] https://docs.python.org/3.5/library/stdtypes.html#str
[116] https://docs.python.org/3.5/library/stdtypes.html#str
[117] https://docs.python.org/3.5/library/datetime.html#datetime.datetime
[118] https://docs.python.org/3.5/library/stdtypes.html#str

class piwheels.states.**MasterStats**

piwheels.states.**mkdir_override_symlink**(*pkg_dir*)
Make *pkg_dir*, replacing any existing symlink in its place. See the notes in `TheScribe.write_package_index()` for more information.

12.21 piwheels.ranges

A set of utility routines for efficiently tracking byte ranges within a stream. These are used to track which chunks of a file have been received during file transfers from build slaves.

See *FileJuggler* (page 47) for the usage of these functions.

piwheels.ranges.**consolidate**(*ranges*)
Given a list of *ranges* in ascending order, this generator function returns the list with any overlapping ranges consolidated into individual ranges. For example:

```
>>> list(consolidate([range(0, 5), range(4, 10)]))
[range(0, 10)]
>>> list(consolidate([range(0, 5), range(5, 10)]))
[range(0, 10)]
>>> list(consolidate([range(0, 5), range(6, 10)]))
[range(0, 5), range(6, 10)]
```

piwheels.ranges.**exclude**(*ranges*, *ex*)
Given a list of non-overlapping *ranges* in ascending order, and a range *ex* to exclude, this generator function returns *ranges* with all values covered by *ex* removed from any contained ranges. For example:

```
>>> list(exclude([range(10)], range(2)))
[range(2, 10)]
>>> list(exclude([range(10)], range(2, 4)))
[range(0, 2), range(4, 10)]
```

piwheels.ranges.**intersect**(*range1*, *range2*)
Given two ranges *range1* and *range2* (which must both have a step of 1), returns the range formed by the intersection of the two ranges, or `None` if the ranges do not overlap. For example:

```
>>> intersect(range(10), range(5))
range(0, 5)
>>> intersect(range(10), range(10, 2))
>>> intersect(range(10), range(2, 5))
range(2, 5)
```

piwheels.ranges.**split**(*ranges*, *i*)
Given a list of non-overlapping *ranges* in ascending order, this generator function returns the list with the range containing *i* split into two ranges, one ending at *i* and the other starting at *i*. If *i* is not contained in any of the ranges, then *ranges* is returned unchanged. For example:

```
>>> list(split([range(10)], 5))
[range(0, 5), range(5, 10)]
>>> list(split([range(10)], 0))
[range(0, 10)]
>>> list(split([range(10)], 20))
[range(0, 10)]
```

CHAPTER 13

License

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Python Module Index

p

piwheels.initdb, 49
piwheels.master.big_brother, 48
piwheels.master.db, 38
piwheels.master.file_juggler, 47
piwheels.master.seraph, 44
piwheels.master.slave_driver, 44
piwheels.master.the_architect, 44
piwheels.master.the_oracle, 40
piwheels.master.the_secretary, 49
piwheels.ranges, 59
piwheels.remove, 50
piwheels.states, 54
piwheels.tasks, 52
piwheels.transport, 50

Index

Symbols

-abi ABI
    piw-import command line option, 16
-builds-queue ADDR
    piw-master command line option, 4
-control-queue ADDR
    piw-master command line option, 4
    piw-monitor command line option, 9
    piw-sense command line option, 11
-db-queue ADDR
    piw-master command line option, 4
-dev-mode
    piw-master command line option, 4
-drop
    piw-logger command line option, 22
-duration DURATION
    piw-import command line option, 16
-file-queue ADDR
    piw-master command line option, 4
-format FORMAT
    piw-logger command line option, 21
-fs-queue ADDR
    piw-master command line option, 4
-import-queue ADDR
    piw-import command line option, 16
    piw-master command line option, 4
    piw-rebuild command line option, 17
    piw-remove command line option, 20
-log-queue ADDR
    piw-logger command line option, 22
    piw-master command line option, 4
-output FILE
    piw-import command line option, 16
-package PACKAGE
    piw-import command line option, 15
-package-version VERSION
    piw-import command line option, 15
-pypi-simple URL
    piw-master command line option, 4
-pypi-xmlrpc URL
    piw-master command line option, 4
-slave-queue ADDR
    piw-master command line option, 4
-stats-queue ADDR
    piw-master command line option, 4
-status-queue ADDR
    piw-master command line option, 4
    piw-monitor command line option, 9
    piw-sense command line option, 11
-version
    piw-import command line option, 15
    piw-initdb command line option, 13
    piw-logger command line option, 21
    piw-master command line option, 3
    piw-monitor command line option, 9
    piw-rebuild command line option, 17
    piw-remove command line option, 19
    piw-sense command line option, 11
    piw-slave command line option, 7
-c FILE, -configuration FILE
    piw-import command line option, 15
    piw-initdb command line option, 13
    piw-logger command line option, 21
    piw-master command line option, 3
    piw-monitor command line option, 9
    piw-rebuild command line option, 17
    piw-remove command line option, 19
    piw-sense command line option, 11
    piw-slave command line option, 7
-d DSN, -dsn DSN
    piw-initdb command line option, 13
    piw-master command line option, 3
-d, -delete
    piw-import command line option, 16
-h, -help
    piw-import command line option, 15
    piw-initdb command line option, 13
    piw-logger command line option, 21
    piw-master command line option, 3
    piw-monitor command line option, 9
    piw-rebuild command line option, 17
    piw-remove command line option, 19
    piw-sense command line option, 11
    piw-slave command line option, 7
-l FILE, -log-file FILE
    piw-import command line option, 15
    piw-initdb command line option, 13

piw-logger command line option, 21
piw-master command line option, 3
piw-rebuild command line option, 17
piw-remove command line option, 19
piw-slave command line option, 7
-m HOST, -master HOST
piw-slave command line option, 7
-o PATH, -output-path PATH
piw-master command line option, 4
-q, -quiet
piw-import command line option, 15
piw-initdb command line option, 13
piw-logger command line option, 21
piw-master command line option, 3
piw-rebuild command line option, 17
piw-remove command line option, 19
piw-slave command line option, 7
-r DEGREES, -rotate DEGREES
piw-sense command line option, 11
-s REASON, -skip REASON
piw-remove command line option, 20
-t DURATION, -timeout DURATION
piw-slave command line option, 7
-u NAME, -user NAME
piw-initdb command line option, 14
-v, -verbose
piw-import command line option, 15
piw-initdb command line option, 13
piw-logger command line option, 21
piw-master command line option, 3
piw-rebuild command line option, 17
piw-remove command line option, 19
piw-slave command line option, 7
-y, -yes
piw-import command line option, 16
piw-initdb command line option, 14
piw-rebuild command line option, 17
piw-remove command line option, 20

A

add_new_package() (*piwheels.master.db.Database method*), 38
add_new_package() (*piwheels.master.the_oracle.DbClient method*), 42
add_new_package_version() (*piwheels.master.db.Database method*), 38
add_new_package_version() (*piwheels.master.the_oracle.DbClient method*), 42
as_message() (*piwheels.states.BuildState method*), 55
as_message() (*piwheels.states.FileState method*), 54

B

BigBrother (*class in piwheels.master.big_brother*), 48
bind() (*piwheels.transport.Socket method*), 50
BuildState (*class in piwheels.states*), 54

C

close() (*piwheels.master.big_brother.BigBrother method*), 48
close() (*piwheels.master.slave_driver.SlaveDriver method*), 44
close() (*piwheels.master.the_architect.TheArchitect method*), 44
close() (*piwheels.master.the_oracle.TheOracle method*), 40
close() (*piwheels.master.the_secretary.TheSecretary method*), 49
close() (*piwheels.tasks.Task method*), 52
close() (*piwheels.transport.Socket method*), 51
connect() (*piwheels.transport.Socket method*), 51
consolidate() (*in module piwheels.ranges*), 59
Context (*class in piwheels.transport*), 50
current_transfer() (*piwheels.master.file_juggler.FileJuggler method*), 47

D

Database (*class in piwheels.master.db*), 38
DbClient (*class in piwheels.master.the_oracle*), 42
delete_build() (*piwheels.master.db.Database method*), 38
delete_build() (*piwheels.master.the_oracle.DbClient method*), 42
delete_package() (*piwheels.master.db.Database method*), 38
delete_package() (*piwheels.master.the_oracle.DbClient method*), 42
delete_version() (*piwheels.master.db.Database method*), 38
delete_version() (*piwheels.master.the_oracle.DbClient method*), 42
detect_users() (*in module piwheels.initdb*), 49
detect_version() (*in module piwheels.initdb*), 50
do_allpkgs() (*piwheels.master.the_oracle.TheOracle method*), 40
do_allvers() (*piwheels.master.the_oracle.TheOracle method*), 40
do_built() (*piwheels.master.slave_driver.SlaveDriver method*), 45
do_busy() (*piwheels.master.slave_driver.SlaveDriver method*), 45
do_bye() (*piwheels.master.slave_driver.SlaveDriver method*), 45
do_delbuild() (*piwheels.master.the_oracle.TheOracle method*), 40

do_delpkg() (piwheels.master.the_oracle.TheOracle method), 40
do_delver() (piwheels.master.the_oracle.TheOracle method), 40
do_expect() (piwheels.master.file_juggler.FileJuggler method), 47
do_filedeps() (piwheels.master.the_oracle.TheOracle method), 40
do_getabis() (piwheels.master.the_oracle.TheOracle method), 40
do_getdesc() (piwheels.master.the_oracle.TheOracle method), 40
do_getpypi() (piwheels.master.the_oracle.TheOracle method), 40
do_getsearch() (piwheels.master.the_oracle.TheOracle method), 40
do_getskip() (piwheels.master.the_oracle.TheOracle method), 40
do_getstats() (piwheels.master.the_oracle.TheOracle method), 40
do_hello() (piwheels.master.slave_driver.SlaveDriver method), 45
do_idle() (piwheels.master.slave_driver.SlaveDriver method), 45
do_loadrwp() (piwheels.master.the_oracle.TheOracle method), 41
do_logbuild() (piwheels.master.the_oracle.TheOracle method), 41
do_logdownload() (piwheels.master.the_oracle.TheOracle method), 41
do_logjson() (piwheels.master.the_oracle.TheOracle method), 41
do_logpage() (piwheels.master.the_oracle.TheOracle method), 41
do_logproject() (piwheels.master.the_oracle.TheOracle method), 41
do_logsearch() (piwheels.master.the_oracle.TheOracle method), 41
do_newpkg() (piwheels.master.the_oracle.TheOracle method), 41
do_newver() (piwheels.master.the_oracle.TheOracle method), 41
do_pkgdeleted() (piwheels.master.the_oracle.TheOracle method), 41
do_pkgexists() (piwheels.master.the_oracle.TheOracle method), 41
do_pkgfiles() (piwheels.master.the_oracle.TheOracle method), 41
do_projfiles() (piwheels.master.the_oracle.TheOracle method), 41
do_projvers() (piwheels.master.the_oracle.TheOracle method), 41
do_remove() (in module piwheels.remove), 50
do_saverwp() (piwheels.master.the_oracle.TheOracle method), 41
do_sent() (piwheels.master.slave_driver.SlaveDriver method), 45
do_setdesc() (piwheels.master.the_oracle.TheOracle method), 41
do_setpypi() (piwheels.master.the_oracle.TheOracle method), 41
do_skippkg() (piwheels.master.the_oracle.TheOracle method), 41
do_skipver() (piwheels.master.the_oracle.TheOracle method), 42
do_unyankver() (piwheels.master.the_oracle.TheOracle method), 42
do_verexists() (piwheels.master.the_oracle.TheOracle method), 42
do_verfiles() (piwheels.master.the_oracle.TheOracle method), 42
do_verify() (piwheels.master.file_juggler.FileJuggler method), 47
do_versdeleted() (piwheels.master.the_oracle.TheOracle method), 42
do_yankver() (piwheels.master.the_oracle.TheOracle method), 42
DownloadState (class in piwheels.states), 56
drain() (piwheels.transport.Socket method), 51

E

every() (piwheels.tasks.Task method), 52
exclude() (in module piwheels.ranges), 59
expect() (piwheels.master.file_juggler.FsClient method), 48

F

FileJuggler (*class in piwheels.master.file_juggler*), 47
files
    piw-logger command line option, 21
files (*piwheels.states.BuildState attribute*), 55
FileState (*class in piwheels.states*), 54
force() (*piwheels.tasks.Task method*), 52
from_message() (*piwheels.states.BuildState class method*), 55
from_message() (*piwheels.states.FileState class method*), 54
FsClient (*class in piwheels.master.file_juggler*), 48

G

get_all_package_versions() (*piwheels.master.db.Database method*), 38
get_all_package_versions() (*piwheels.master.the_oracle.DbClient method*), 42
get_all_packages() (*piwheels.master.db.Database method*), 38
get_all_packages() (*piwheels.master.the_oracle.DbClient method*), 42
get_build_abis() (*piwheels.master.db.Database method*), 38
get_build_abis() (*piwheels.master.the_oracle.DbClient method*), 42
get_build_queue() (*piwheels.master.db.Database method*), 38
get_connection() (*in module piwheels.initdb*), 50
get_file_apt_dependencies() (*piwheels.master.db.Database method*), 38
get_file_apt_dependencies() (*piwheels.master.the_oracle.DbClient method*), 42
get_package_description() (*piwheels.master.db.Database method*), 38
get_package_description() (*piwheels.master.the_oracle.DbClient method*), 42
get_package_files() (*piwheels.master.db.Database method*), 38
get_package_files() (*piwheels.master.the_oracle.DbClient method*), 42
get_project_files() (*piwheels.master.db.Database method*), 38
get_project_files() (*piwheels.master.the_oracle.DbClient method*), 42
get_project_versions() (*piwheels.master.db.Database method*), 38
get_project_versions() (*piwheels.master.the_oracle.DbClient method*), 43
get_pypi_serial() (*piwheels.master.db.Database method*), 38
get_pypi_serial() (*piwheels.master.the_oracle.DbClient method*), 43
get_script() (*in module piwheels.initdb*), 50
get_search_index() (*piwheels.master.db.Database method*), 38
get_search_index() (*piwheels.master.the_oracle.DbClient method*), 43
get_statistics() (*piwheels.master.db.Database method*), 38
get_statistics() (*piwheels.master.the_oracle.DbClient method*), 43
get_version_files() (*piwheels.master.db.Database method*), 38
get_version_files() (*piwheels.master.the_oracle.DbClient method*), 43
get_version_skip() (*piwheels.master.db.Database method*), 39
get_version_skip() (*piwheels.master.the_oracle.DbClient method*), 43
get_versions_deleted() (*piwheels.master.db.Database method*), 39
get_versions_deleted() (*piwheels.master.the_oracle.DbClient method*), 43

H

handle_back() (*piwheels.master.seraph.Seraph method*), 44
handle_build() (*piwheels.master.slave_driver.SlaveDriver method*), 45
handle_control() (*piwheels.master.big_brother.BigBrother method*), 48
handle_control() (*piwheels.master.slave_driver.SlaveDriver method*), 46
handle_control() (*piwheels.tasks.PauseableTask method*), 53
handle_control() (*piwheels.tasks.Task method*), 52
handle_db_request() (*piwheels.master.the_oracle.TheOracle method*), 42
handle_delete() (*piwheels.master.slave_driver.SlaveDriver method*), 46
handle_file() (*piwheels.master.file_juggler.FileJuggler method*), 48
handle_front() (*piwheels.master.seraph.Seraph*

method), 44
handle_fs_request() (*piwheels.master.file_juggler.FileJuggler method*), 48
handle_input() (*piwheels.master.the_secretary.TheSecretary method*), 49
handle_output() (*piwheels.master.the_secretary.TheSecretary method*), 49
handle_slave() (*piwheels.master.slave_driver.SlaveDriver method*), 46
hwm (*piwheels.transport.Socket attribute*), 51

I

intersect() (*in module piwheels.ranges*), 59

J

JSONState (*class in piwheels.states*), 58

K

kill_slave() (*piwheels.master.slave_driver.SlaveDriver method*), 46

L

list_slaves() (*piwheels.master.slave_driver.SlaveDriver method*), 46
load_rewrites_pending() (*piwheels.master.db.Database method*), 39
load_rewrites_pending() (*piwheels.master.the_oracle.DbClient method*), 43
log_build() (*piwheels.master.db.Database method*), 39
log_build() (*piwheels.master.the_oracle.DbClient method*), 43
log_download() (*piwheels.master.db.Database method*), 39
log_download() (*piwheels.master.the_oracle.DbClient method*), 43
log_json() (*piwheels.master.db.Database method*), 39
log_json() (*piwheels.master.the_oracle.DbClient method*), 43
log_page() (*piwheels.master.db.Database method*), 39
log_page() (*piwheels.master.the_oracle.DbClient method*), 43
log_project() (*piwheels.master.db.Database method*), 39
log_project() (*piwheels.master.the_oracle.DbClient method*), 43
log_search() (*piwheels.master.db.Database method*), 39
log_search() (*piwheels.master.the_oracle.DbClient method*), 43
logged() (*piwheels.states.BuildState method*), 55

M

main() (*in module piwheels.initdb*), 49
main() (*in module piwheels.remove*), 50
MasterStats (*class in piwheels.states*), 58
mkdir_override_symlink() (*in module piwheels.states*), 59

N

new_transfer() (*piwheels.master.file_juggler.FileJuggler method*), 48
next_file (*piwheels.states.BuildState attribute*), 55

O

once() (*piwheels.master.file_juggler.FileJuggler method*), 48
once() (*piwheels.master.the_secretary.TheSecretary method*), 49
once() (*piwheels.tasks.Task method*), 53

P

package
    piw-remove command line option, 19
package_marked_deleted() (*piwheels.master.db.Database method*), 39
package_marked_deleted() (*piwheels.master.the_oracle.DbClient method*), 43
PageState (*class in piwheels.states*), 58
parse_statements() (*in module piwheels.initdb*), 50
pause() (*piwheels.tasks.Task method*), 53
PauseableTask (*class in piwheels.tasks*), 53
piw-import command line option
    -abi ABI, 16
    -duration DURATION, 16
    -import-queue ADDR, 16
    -output FILE, 16
    -package PACKAGE, 15
    -package-version VERSION, 15
    -version, 15
    -c FILE, -configuration FILE, 15
    -d, -delete, 16
    -h, -help, 15
    -l FILE, -log-file FILE, 15
    -q, -quiet, 15
    -v, -verbose, 15
    -y, -yes, 16
piw-initdb command line option
    -version, 13
    -c FILE, -configuration FILE, 13

-d DSN, -dsn DSN, 13
-h, -help, 13
-l FILE, -log-file FILE, 13
-q, -quiet, 13
-u NAME, -user NAME, 14
-v, -verbose, 13
-y, -yes, 14
piw-logger command line option
-drop, 22
-format FORMAT, 21
-log-queue ADDR, 22
-version, 21
-c FILE, -configuration FILE, 21
-h, -help, 21
-l FILE, -log-file FILE, 21
-q, -quiet, 21
-v, -verbose, 21
files, 21
piw-master command line option
-builds-queue ADDR, 4
-control-queue ADDR, 4
-db-queue ADDR, 4
-dev-mode, 4
-file-queue ADDR, 4
-fs-queue ADDR, 4
-import-queue ADDR, 4
-log-queue ADDR, 4
-pypi-simple URL, 4
-pypi-xmlrpc URL, 4
-slave-queue ADDR, 4
-stats-queue ADDR, 4
-status-queue ADDR, 4
-version, 3
-c FILE, -configuration FILE, 3
-d DSN, -dsn DSN, 3
-h, -help, 3
-l FILE, -log-file FILE, 3
-o PATH, -output-path PATH, 4
-q, -quiet, 3
-v, -verbose, 3
piw-monitor command line option
-control-queue ADDR, 9
-status-queue ADDR, 9
-version, 9
-c FILE, -configuration FILE, 9
-h, -help, 9
piw-rebuild command line option
-import-queue ADDR, 17
-version, 17
-c FILE, -configuration FILE, 17
-h, -help, 17
-l FILE, -log-file FILE, 17
-q, -quiet, 17
-v, -verbose, 17
-y, -yes, 17
piw-remove command line option
-import-queue ADDR, 20
-version, 19
-c FILE, -configuration FILE, 19
-h, -help, 19
-l FILE, -log-file FILE, 19
-q, -quiet, 19
-s REASON, -skip REASON, 20
-v, -verbose, 19
-y, -yes, 20
package, 19
version, 19
piw-sense command line option
-control-queue ADDR, 11
-status-queue ADDR, 11
-version, 11
-c FILE, -configuration FILE, 11
-h, -help, 11
-r DEGREES, -rotate DEGREES, 11
piw-slave command line option
-version, 7
-c FILE, -configuration FILE, 7
-h, -help, 7
-l FILE, -log-file FILE, 7
-m HOST, -master HOST, 7
-q, -quiet, 7
-t DURATION, -timeout DURATION, 7
-v, -verbose, 7
piwheels.initdb (*module*), 49
piwheels.master.big_brother (*module*), 48
piwheels.master.db (*module*), 38
piwheels.master.file_juggler (*module*), 47
piwheels.master.seraph (*module*), 44
piwheels.master.slave_driver (*module*), 44
piwheels.master.the_architect (*module*), 44
piwheels.master.the_oracle (*module*), 40
piwheels.master.the_secretary (*module*), 49
piwheels.ranges (*module*), 59
piwheels.remove (*module*), 50
piwheels.states (*module*), 54
piwheels.tasks (*module*), 52
piwheels.transport (*module*), 50
poll() (*piwheels.tasks.Task method*), 53
poll() (*piwheels.transport.Poller method*), 52
poll() (*piwheels.transport.Socket method*), 51
Poller (*class in piwheels.transport*), 52
ProjectState (*class in piwheels.states*), 58

Q

quit() (*piwheels.master.the_architect.TheArchitect method*), 44
quit() (*piwheels.tasks.Task method*), 53

R

recv() (*piwheels.transport.Socket method*), 51
recv_addr_msg() (*piwheels.transport.Socket method*), 51
recv_msg() (*piwheels.transport.Socket method*), 51

recv_multipart() (*piwheels.transport.Socket method*), 51
register() (*piwheels.tasks.Task method*), 53
register() (*piwheels.transport.Poller method*), 52
remove_expired() (*piwheels.master.slave_driver.SlaveDriver method*), 46
resume() (*piwheels.tasks.Task method*), 53
run() (*piwheels.tasks.Task method*), 53

S

save_rewrites_pending() (*piwheels.master.db.Database method*), 39
save_rewrites_pending() (*piwheels.master.the_oracle.DbClient method*), 43
SearchState (*class in piwheels.states*), 57
send() (*piwheels.transport.Socket method*), 51
send_addr_msg() (*piwheels.transport.Socket method*), 51
send_msg() (*piwheels.transport.Socket method*), 51
send_multipart() (*piwheels.transport.Socket method*), 51
Seraph (*class in piwheels.master.seraph*), 44
set_package_description() (*piwheels.master.db.Database method*), 39
set_package_description() (*piwheels.master.the_oracle.DbClient method*), 43
set_pypi_serial() (*piwheels.master.db.Database method*), 39
set_pypi_serial() (*piwheels.master.the_oracle.DbClient method*), 43
skip_package() (*piwheels.master.db.Database method*), 39
skip_package() (*piwheels.master.the_oracle.DbClient method*), 43
skip_package_version() (*piwheels.master.db.Database method*), 39
skip_package_version() (*piwheels.master.the_oracle.DbClient method*), 43
skip_slave() (*piwheels.master.slave_driver.SlaveDriver method*), 46
SlaveDriver (*class in piwheels.master.slave_driver*), 44
SlaveState (*class in piwheels.states*), 55
SlaveStats (*class in piwheels.states*), 58
sleep_slave() (*piwheels.master.slave_driver.SlaveDriver method*), 46
Socket (*class in piwheels.transport*), 50
socket() (*piwheels.tasks.Task method*), 53
split() (*in module piwheels.ranges*), 59
subscribe() (*piwheels.transport.Socket method*), 51

T

Task (*class in piwheels.tasks*), 52
TaskQuit, 52
test_package() (*piwheels.master.db.Database method*), 39
test_package() (*piwheels.master.the_oracle.DbClient method*), 43
test_package_version() (*piwheels.master.db.Database method*), 39
test_package_version() (*piwheels.master.the_oracle.DbClient method*), 43
TheArchitect (*class in piwheels.master.the_architect*), 44
TheOracle (*class in piwheels.master.the_oracle*), 40
TheSecretary (*class in piwheels.master.the_secretary*), 49
TransferDone, 47
TransferError, 47
TransferIgnoreChunk, 47
transfers_done (*piwheels.states.BuildState attribute*), 55
TransferState (*class in piwheels.states*), 56

U

unregister() (*piwheels.transport.Poller method*), 52
unsubscribe() (*piwheels.transport.Socket method*), 51
unyank_version() (*piwheels.master.db.Database method*), 39
unyank_version() (*piwheels.master.the_oracle.DbClient method*), 43
update_build_queue() (*piwheels.master.the_architect.TheArchitect method*), 44

V

verified() (*piwheels.states.FileState method*), 54
verify() (*piwheels.master.file_juggler.FsClient method*), 48
version
    piw-remove command line option, 19

W

wake_slave() (*piwheels.master.slave_driver.SlaveDriver method*), 46

Y

yank_version() (*piwheels.master.db.Database method*), 39

yank_version() (*piwheels.master.the_oracle.DbClient method*), 44