

# ApyShell/ApyEngine Programming Guide

Version 1.0

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## Introduction

ApyEngine is an embeddable interpreter for a subset of the Python 3 language. It runs scripts written in it's version of Python, in a relatively safe, contained way. It can not run anything on it's own, but is designed to be embedded in a host application.

ApyShell is an example of such a host. It can run as a stand-alone program, executing scripts via it's embedded apyengine. It also provides the support structure to manage script files, various directories, and extensions to the engine itself.

And there are the Extension modules. These add controlled, on-demand functionality to the engine to perform specialized tasks. Extensions are written in full Python, and present a uniform interface to the scripts. Many extensions are included with the source distribution, and it's easy to create new ones.

All of this leads to a full-featured scripting environment that can be added to nearly any Python 3 application. It's easy to write scripts for, yet it restricts the abilities of those scripts to cause unexpected or unwanted behavior.

Why use it?

- it's safer than full Python
- it's easier for less-experienced coders to write in
- it's easily merged into an enclosing host application
- It's as powerful as you want to make it, but *only* as powerful as you want

You can grab your own copy at: [GitHub](#) . You can download just the apyengine alone, or the full apyshell (which includes apyengine and extensions).

## History

The seeds of this project started a few years ago. I had written an Android application for cellular engineers that performed a variety of network tests, and logged the results. It worked well, but adding new test functionality meant re-releasing the app, which became tiresome.

I wanted to give the RF engineers the ability to add new tests, and maybe create their own. That meant a scripting language, easy to code in, and with support for their specific needs. And it had to be safe, so a rogue or defective script could not compromise the test devices.

I could have created a new scripting language, but I picked Python for it's flexibility and vast training resources. Plus, I've been working with Python since the early 1990's, so it's familiar.

The original prototype of the new app was written in Python 2.7, using Kivy as it's UI on Android. It worked, but was pretty primitive compared to the current version.

The project ran it's course, and the app was retired. I took the basic concepts, rewrote the entire codebase from scratch in Python 3, and began using it my own networks. The engine is embedded in my apyshell framework, and has been running system management, Home Automation, and other tasks for a few years now.

# Installation

*This document assumes that you are using Linux, unless otherwise noted.*

Before you install apyshell, you'll need to download and install "apyengine". Clone the project from GitHub like this: `git clone https://github.com/closecrowd/apyengine.git`. Change to the "apyengine" directory, and run `pip install .` to install the engine core.

The apyengine has no **mandatory** external requirements. However, if you want to use the numpy module (see Modules below), you'll need to have that installed in your system.

Likewise, apyshell has no **required** dependencies outside of it's project, and what Python normally provides. But several of the optional Extensions (see Extensions below) **do** require 3rd-party resources. See the pages documenting the Extensions for more details.

Next, clone the apyshell project from GitHub with: `git clone https://github.com/closecrowd/apysHELL.git`. Change to the "apysHELL" directory, and make any changes that you need to apysHELL.py – particularly the default directory paths and extension options. Then copy the entire directory tree to your desired location. I use `/opt/apysHELL` by default, but you may change them.

The default directories for scripts and extension files in apysHELL.py are:

```
# default directory paths
basedir = '/opt/apysHELL/scripts'      # script base directory
extensiondir = '/opt/apysHELL/extensions' # extension base dir
```

You can override these when launching the program with the `-b` and `-e` options.

These paths are a key piece of the security mechanism. Scripts may only be run from the basedir (or subdirs below it), and only extensions present in the extensiondir directory are available to the scripts.

You can control which scripts may run, and which extensions the scripts can use, by controlling the contents of these directories.

Note: 'basedir' must be a single path, which 'extensiondir' may be a list of paths, separated by commas.

# Running ApyShell

Once you have the files, executing a script is as easy as:

```
./apyshell.py scriptname
```

Assuming that you have created the default directories and moved everything to the right place, **and** have a script named “scriptname.apy”, it’ll start running.

Hint: copy the entire source tree to “/opt/apyshell”, and all the defaults will work out of the box. You can, of course, change the default directories in apyshell.py. And you can set the directories with command-line options. This is useful for running instances of the program with different Extension and script environments.

Built-in help is available for the command-line options:

```
> ./apyshell.py -h
```

```
apyshell.py script [ options ]
```

```
script          The script file to execute (required). The .apy is optional
```

```
-h, --help      This message
```

```
-a, --args      Optional argument string to pass to the script
```

```
-i, --initscript A script to execute before the specified script
```

```
-b, --basedir   Base directory for scripts (use , for multiple paths)
```

```
-e, --extensiondir Base directory for extensions (use , for multiple paths)
```

```
-o, --extensionopts A list of options key:value pairs to pass to extensions
```

```
-p, --pidfile   Write a file with the shell's current PID
```

```
-g, --global    All script variables are global
```

```
-v, --verbose   Debug output
```

Note: the options (if any) come **AFTER** the name of the script to execute (and the .apy extension to the script name is optional). If the directory containing apyshell.py is on the path, you can even dispense with the ./ prefix.

To run the included “demo.apy” script at the default locations, just enter:

```
/opt/apyshell/apyshell.py demo
```

Now, say we have a classroom setup where students upload their scripts to a specific directory, and run them against a limited set of extensions. This would be pretty easy to set up with a web server and a bit of CGI. Let’s put the student’s script files in “/class/scripts”, and the curated extensions in “/teacher/apy/extensions”. The program itself can be in /opt/apyshell. To run a script named “prog1”, the command would be:

```
/opt/apyshell/apyshell.py prog1 -b /class/scripts -e /teacher/apy/extensions
```

The scripts in “/class/scripts” can **only** use extensions in “/teacher/apy/extensions”, and can’t wreak havoc on the host system.

Here’s a detailed listing of each option:

-h, --help                This message  
-a, --args                Optional argument string to pass to the script

You can pass an argument string to your script with this option. For instance, adding -a “myargument” will allow your script to use `getSysVar_ (“args”)` to retrieve it. The value of “args” will be exactly what you pass in “-a”.

-i, --initscript        A script to execute before the specified script

You can specify a .apy script to execute **before** your script. Since the global state is preserved after the initial script ends, this is an excellent way to initialize variables. Or if you have user-defined functions that are shared among many scripts, this is a way to have them all in one place. When the initial script ends, the main script will be loaded and executed.

-b, --basedir            Base directory for scripts (use , for multiple paths)

This is the top of the hierarchy of scripts. Apyshell can only execute .apy scripts located in this directory, or in sub-directories below it. You can specify **multiple** base paths by separating them with commas (.). For example:

-b “/teacher/commonscripts,/class/scripts”

Now both of these paths will be searched for the named .apy files.

-e, --extensiondir      Base directory for extensions (use , for multiple paths)

This is the directory (or list of directories) where the Extension modules are kept. Only the Extensions in these directories are available to the `loadExtension_()` command. Like “-b”, separate the paths with commas (.).

-o, --extensionopts    A list of options key:value pairs to pass to extensions

Some Extensions have options controlling various locations or abilities. There are defaults for every Extension, but you can over-ride those defaults with “-o”. For example, the “sqliteext” Extension has two options in `apyshell.py`:

```
'sql_root': '/opt/apysHELL/files'    - The path to use for database files  
'sql_ext': 'db'                      - The extension to append for db files.
```

If you wanted to change where you stored the Sqlite3 database files, **and** the file extension, you would use something like this:

```
-o 'sql_root:/opt/apysHELL/files,sql_ext:sql'
```

Note that the options are key:value pairs, and multiple options are separated by commas (.). Spaces are okay, no quotes (apart from the enclosing pair).

```
-p, --pidfile      Write a file with the shell's current PID
```

When you run an apysHELL script as a background daemon, it's useful to store it's Process ID in a file. This makes it easy for application management system to verify that it's still running. So this option tries to write the PID of the Python process running apysHELL to the path and file specified. It doesn't do any checking of the path – so if you're running as root, pay attention to the filepath.

Example:

```
-p /var/run/apysHELL.pid
```

If the script ends in any sort of controlled manner, apysHELL will try to remove the pidfile **if** it was successful in creating it on entry.

```
-g, --global      All script variables are global
```

In standard Python, variables defined in a function are local to that function. If this flag is set, **all** variables everywhere are global. Bad form and all, but useful in some cases. The default is False – variable scope follow the Python norms.

```
-v, --verbose      Debug output
```

Prints some extra debugging info on the console.



## Writing .apy Scripts

Now to the good part – writing scripts to run under ApyShell. If you know basic Python, this will look very familiar. The ApyEngine is a Python interpreter – it uses Python’s own built-in parser and interpreter to execute your scripts. But there are some differences.

Things not in .apy:

- Classes. While the engine is composed of many Python classes, the .apy scripts do not allow user-defined classes. Maybe in a future version...

- Imports. At least, in the sense of regular Python modules. This is a restricted, controlled environment. Adding new features is done by Extensions, which are carefully written to perform functions in a secure manner. And since we don’t have classes, it’s be hard to use most Python modules anyways.

An exception to this are the small number of modules available through the “install\_()” command. These are Python modules, but with the function names modified to fit the engine’s naming conventions. See the sections on Modules later for more information.

- Globals. You can’t declare a variable to be global. There are work-arounds, however.

- Lambda, Decorators. Not supported.

- Generators, Yield. Hard to use without classes – not supported.

- Exec, getattr. Nope. There are ways to execute arbitrary commands, if allowed by the local installation.

But look at all the language features that **are** in apy:

- for loops, while loops, if-then-elif-else conditionals
- if-expressions: `out = one_thing if TEST else other`
- try-except (including 'finally')
- function definitions with `def`
- advanced slicing: `a[::-1]`, `array[-3:, :, ::2]`
- arrays, lists, tuples, dicts
- all of the standard Python types (including objects)
- list comprehension `out = [sqrt(i) for i in values]`
- eval (safely in the context of the engine)

In addition, the engine supports extensive thread-safety, since many of the Extension modules are multi-threaded under the hood.

## Some conventions

The engine enforces a few naming conventions designed to improve security and readability. It generally follows the Python scheme for naming functions and variables, **except** that your script may not define anything ending with underscore(\_). That is reserved for functions installed by the system, Extensions, or internally-created variables.

File names (scripts, data files, etc.) are allowed to use: “a-zA-Z0-9-\_”. Directory paths are allowed in some cases (scripts, for instance), but they will be forced to be relative to a host-defined directory.

## ApyShell Built-in Functions

Apyshell itself provides several utility functions that you can call. These functions are always available to scripts:

`install_( modname )`

Installs one of the built-in Python modules so that scripts may use it's commands.

`modname`      the module to install. Must be one of: math, time, json, base64, numpy

Returns True if the module installed okay, False if there was a problem.

`listModules_()`

Returns a list with the names of currently-installed modules.

`loadScript_( filename, persist=False)`

Executes an .apy script with the specified name, and then continues when it finishes. The script file must be located in one of the directory paths specified with the -b option (or the default path). The “.apy” extension is optional – it'll be added automatically if not present.

If the optional ‘persist’ argument is True, then any functions defined in the script will be flagged as persistent, and will not be subject to purging later. This is useful for establishing a library of functions that will stick around after their scripts are done.

Here's an example – three small scripts chained together :

```
# script1.apy
print('script 1 running')
loadScript_('script2')
print('back at script 1')

# script2.apy
print('script 2 running')
loadScript_('script3')
print('back at script 2')

# script3.apy
print('script 3 running')
```

will look like this when run:

```
> apyshell script1
--> script 1 running
--> script 2 running
--> script 3 running
```

```
--> back at script 2
--> back at script 1
```

The symbol table is global across all these scripts – variables and functions defined in a loaded script will be available to the loading script when it gets control back.

The next four functions deal with symbols (variables and functions) in the environment of the scripts, below the apyengine API line:

`isDef_( name )`

Returns True if the symbol named “name” is defined. This can be a variable, or a function.

`listDefs_()`

Returns a list of functions that have been defined in the script(s). This is a good way to test if a common function is present before you try to call it.

`getvar_( vname, default=None )`

Returns the value of the named script variable, if it exists. Otherwise, return a default value. This is normally called by the **host** application to pass data into the script environment, but it can be called from a script as well. This leads to some interesting meta-programming options.

`setvar_( vname, val )`

This function will set the value of a script variable **if**: it already exists, and it’s not set as Read-Only. If the variable exists, and we pass in None for the value, the variable will be deleted from the engine. Normally used by the host application to control a script, but callable from scripts as well.

The next function gives the scripts limited access to data held in the engine, and managed by the host application.

`getSysVar_( name, default=None )`

Get a value from the “SysVar” dict, or a default value. SysVar is a dictionary maintained by the engine to pass values between the host side and the script environment. The host application puts useful things in there (such as command-line arguments, hostname, etc.), and the scripts can read them. Scripts can only **get** these values – the host application can call an engine API function to **set** them.

The next two functions let scripts directly execute the apy dialect of Python:

`check_( code )`

This function does a syntax check of the expression in “code”, but does NOT execute it. Useful if you want to check the expression before you pass it to `eval_()`.

It returns the string “OK” if it’s valid code, “ERR” plus a descriptive message if not. If the “code” argument is empty, returns None.

`eval_( cmd )`

This function executes a Python statement in the context of the engine. It has all of the restrictions of the script that it’s executing in, and shares state with it. This makes it possible to write a REPL, or even a mini-shell within the apy script. You **could** even do something like:

```
ret = eval_('eval_( "1 + 1" )')
```

but that gets silly.

The return value is the result of the expression (if any), or None if there was no return from the expression. If there was an error, a string will be returned with an error message.

The last two functions end the running of the scripts. A script will normally run until it falls off the end, when it will naturally finish processing. There are two ways to leave in the middle of a running script:

`stop_( ret )`

This function will **gracefully** stop a script and return to apyshell, with an optional integer return code. If this is called in a nested script (i.e. started by `loadScript_()` in your script), it will exit all the way back out to apyshell.

`exit_( ret )`

This function exits the apyshell interpreter back to the operating system. No cleanup is done – any pidfile is left hanging.

## An example

Here's a small example script showing some of these features. This script (along with many others), is included in the GitHub repository.

### demo.apy

```
#
# demo.apy
#
# This little script demonstrates some of the basic
# features of apyshell.
#
# Mark Anacker <closecrowd@pm.me>
# -----

print('Welcome to apyshell!')

# add the 'time' built-ins
install_('time')

# this gives us the following functions from the Python 'time' module:
#
# ctime_, clock_, asctime_, strptime_, monotonic_,
# gmtime_, mktime_, sleep_, time_, strftime_, localtime_
#
# and constants:
#
# altzone_, timezone_, tzname_, daylight_
#
#

eval_('print("hi")')

# grab the time and date
t = asctime_(localtime_())
print('Right now, it is:', t)

# get our hostname passed in by apyshell:
host = getSysVar_('hostname')
print('We are currently running on '+host)

# and the host Python version
ver = getSysVar_('pythonver')
print('Under Python version:', ver)

#
# Extensions
#

# get the list of extensions that may be loaded by scripts
availlist = scanExtensions_()
print('These extensions are available:', availlist)

# and the list of currently-loaded ones
loadedlist = listExtensions_()
print('These extensions are loaded:', loadedlist)

# load the small utility extension
```

```

loadExtension_('utilext')

# and see the difference
print('Now we can use:', listExtensions_())

# or we can just test for it:
print('Is it loaded:', isExtLoaded_('utilext'))

print('Getting rid of utilext')

# get rid of it...
unloadExtension_('utilext')

# what about now?
print('Is is loaded now:', isExtLoaded_('utilext'))

#
# we can handle exceptions.  cause them, too...
#

print('Exception handling...')

try:
    print('Protected by the try:')
    # fake an error condition
    raise Exception('An error happened')
except Exception as e:
    # note that we give this output line a different prefix...
    print('Except:', str(e), prefix='!!!! ')

print("That's the end for now")

```

When run with “apyshell demo”, this is the output:

```

--> Welcome to apyshell!
--> hi
--> Right now, it is: Mon Nov 27 12:29:01 2023
--> We are currently running on scrooge
--> Under Python version: 3.5
--> These extensions are available: ['mqtttext', 'redisext', 'sqliteext', 'utilext',
'fileext', 'queueext']
--> These extensions are loaded: []
--> Now we can use: ['utilext']
--> Is it loaded: True
--> Getting rid of utilext
--> Is is loaded now: False
--> Exception handling...
--> Protected by the try:
!!!! Except: An error happened at line 79
--> That's the end for now

```





# Modules

As described previously, certain Python modules may be installed by your scripts. If you don't need the functions of a particular module, you can save some memory by simply not installing it.

The key differences between modules and extensions are:

- modules are managed by the engine, while extensions are managed by the host application (in this case, apyshell)
- modules are pre-determined, and are always available for install.
- once installed, modules remain present until apyshell exits.
- modules add new functions directly into the engine. The new functions don't include parts of the module name (unlike extensions).

The functions added by the modules are direct references to the original Python ones, **except** for the underscore (\_) appended to the name. The engine prevents user scripts from defining variables or functions with a trailing \_ - if you see that, you know it's a system-supplied symbol.

The Python base module is imported by the `install_()` command. If the import fails (the module isn't available to the host system), and error message will be printed on the console and the functions won't be available.

There are currently 6 modules available to install: **time**, **json**, **base64**, **math**, **re**, and **numpy**. The following sections list each module and the function names supplied by that module..

## ***Time***

<https://docs.python.org/3/library/time.html>

This module provides various time-related functions. It is a direct mapping of most of the Python 3 standard time module, with names slightly changed.

To use:

```
install_('time')
```

Functions available:

```
ctime_(), clock_(), asctime_(), strptime_(), gmtime_(), mktime_(), sleep_(),  
time_(), strftime_(), localtime_(), monotonic_()
```

Timezone Constants:

```
altzone_ , timezone_ , tzname_ , daylight_
```

## **Json**

<https://docs.python.org/3/library/json.html>

This module is an interface to the standard Python json module.

To use:

```
install_('json')
```

Functions available:

```
jsondumps_(), jsonloads_(), JSONDecoder_(), JSONEncoder_()
```

Note that the JSON module dumps() and loads() functions have been renamed slightly, to avoid a conflict with numpy functions of the same name.

## **Base64**

<https://docs.python.org/3/library/base64.html>

This module provides functions for encoding binary data to printable ASCII characters and decoding such encodings back to binary data.

To use:

```
install_('base64')
```

Functions available:

```
b64encode_(), b64decode_(), urlsafe_b64encode_(), urlsafe_b64decode_()
```

## **Math**

<https://docs.python.org/3/library/math.html>

This module provides access to the mathematical functions defined by the C standard. It provides all of the math functions as of Python 3.5. These calls are equivalent to the Python version, without the module prefix. For example: “cos\_()” is the same as “math.cos()” - apyengine doesn’t support namespaces.

To use:

```
install_('math')
```

Functions available:

```
acos_(), acosh_(), asin_(), asinh_(), atan_(), atan2_(), atanh_(), ceil_(),  
copysign_(), cos_(), cosh_(), degrees_(), exp_(), fabs_(), factorial_(), floor_(),  
fmod_(), frexp_(), fsum_(), hypot_(), isinf_(), isnan_(), ldexp_(), log_(),  
log10_(), log1p_(), modf_(), pow_(), radians_(), sin_(), sinh_(), sqrt_(), tan_(),  
tanh_(), trunc_()
```

Pre-defined constants:

```
e_, pi_, inf_, nan_
```

## Re

<https://docs.python.org/3/library/re.html>

This module provides regular expression matching operations similar to those found in Perl. The functions are the same as the normal Python re module – only the names have been slightly altered to avoid conflicts with other modules.

To use:

```
install_('re')
```

Functions available:

```
recompile_, research_, rematch_, refullmatch_, resplit_, refindall_, refinditer_,  
resub_, resubn_, reescape_, repurge_, reerror_
```

Pre-defined constants:

```
reASCII_, reIGNORECASE_, reLOCALE_, reMULTILINE_, reNOFLAG_, reDOTALL_, reUNICODE_,  
reVERBOSE_, reDEBUG_
```

### Example

```
install_('re')  
  
# this is a sample line from /var/log/secure  
line = 'Dec 22 00:15:04 closecrowd sshd[17642]: User root from 43.156.39.228 not  
allowed because not listed in AllowUsers'  
  
# regex for IP addresses  
ipreg = recompile_(r'(\d{1,3}\.\d{1,3}\.\d{1,3}\.\d{1,3})')  
# regex for the user name  
userreg = recompile_(r'(User\s([a-zA-Z]+?)\s)')  
  
# search the line for all matches  
m = research_(allreg, line)  
# and print the results  
print(m.groups())  
  
--> ('User root from 43.156.39.228', 'root', '43.156.39.228')
```

## Numpy

<https://numpy.org/>

If you have the numpy module installed on your host system, this modules will allow your script to use many of the functions in this extensive package. Familiarity with Numpy is very much encouraged.

To use:

```
install_('numpy')
```

Functions available:

```
Inf_(), NAN_(), abs_(), add_(), alen_(), all_(), amax_(), amin_(), angle_(),
any_(), append_(), arange_(), arccos_(), arccosh_(), arcsin_(), arcsinh_(),
arctan_(), arctan2_(), arctanh_(), argmax_(), argmin_(), argsort_(), argwhere_(),
around_(), array_(), array2string_(), asanyarray_(), asarray_(),
asarray_chkfinite_(), ascontiguousarray_(), asfarray_(), asfortranarray_(),
asmatrix_(), asscalar_(), atleast_1d_(), atleast_2d_(), atleast_3d_(), average_(),
bartlett_(), base_repr_(), bitwise_and_(), bitwise_not_(), bitwise_or_(),
bitwise_xor_(), blackman_(), bool_(), broadcast_(), broadcast_arrays_(), byte_(),
c_(), cdouble_(), ceil_(), cfloat_(), chararray_(), choose_(), clip_(),
clongdouble_(), clongfloat_(), column_stack_(), common_type_(), complex_(),
complex128_(), complex64_(), complex_(), complexfloating_(), compress_(),
concatenate_(), conjugate_(), convolve_(), copy_(), copysign_(), corrcoef_(),
correlate_(), cos_(), cosh_(), cov_(), cross_(), csingle_(), cumprod_(), cumsum_(),
datetime_data_(), deg2rad_(), degrees_(), delete_(), diag_(), diag_indices_(),
diag_indices_from_(), diagflat_(), diagonal_(), diff_(), digitize_(), divide_(),
dot_(), double_(), dsplit_(), dstack_(), dtype_(), e_(), ediff1d_(), empty_(),
empty_like_(), equal_(), exp_(), exp2_(), expand_dims_(), expm1_(), extract_(),
eye_(), fabs_(), fill_diagonal_(), finfo_(), fix_(), flatiter_(), flatnonzero_(),
fliplr_(), flipud_(), float_(), float32_(), float64_(), float_(), floating_(),
floor_(), floor_divide_(), fmax_(), fmin_(), fmod_(), format_parser_(), frexp_(),
frombuffer_(), fromfile_(), fromfunction_(), fromiter_(), frompyfunc_(),
fromregex_(), fromstring_(), fv_(), genfromtxt_(), getbufsize_(), geterr_(),
gradient_(), greater_(), greater_equal_(), hamming_(), hanning_(), histogram_(),
histogram2d_(), histogramdd_(), hsplit_(), hstack_(), hypot_(), i0_(), identity_(),
iinfo_(), imag_(), in1d_(), index_exp_(), indices_(), inexact_(), inf_(), info_(),
infty_(), inner_(), insert_(), int_(), int0_(), int16_(), int32_(), int64_(),
int8_(), int_(), int_asbuffer_(), intc_(), integer_(), interp_(), intersect1d_(),
intp_(), invert_(), ipmt_(), irr_(), iscomplex_(), iscomplexobj_(), isfinite_(),
isfortran_(), isinf_(), isnan_(), isneginf_(), isposinf_(), isreal_(),
isrealobj_(), isscalar_(), issctype_(), iterable_(), ix_(), kaiser_(), kron_(),
ldexp_(), left_shift_(), less_(), less_equal_(), linspace_(), little_endian_(),
load_(), loads_(), loadtxt_(), log_(), log10_(), log1p_(), log2_(), logaddexp_(),
logaddexp2_(), logical_and_(), logical_not_(), logical_or_(), logical_xor_(),
logspace_(), long_(), longcomplex_(), longdouble_(), longfloat_(), longlong_(),
mafromtxt_(), mask_indices_(), mat_(), matrix_(), maximum_(), maximum_sctype_(),
may_share_memory_(), mean_(), median_(), memmap_(), meshgrid_(), mgrid_(),
minimum_(), mintypecode_(), mirr_(), mod_(), modf_(), msort_(), multiply_(),
nan_(), nan_to_num_(), nanargmax_(), nanargmin_(), nanmax_(), nanmin_(), nansum_(),
ndarray_(), ndenumerate_(), ndfromtxt_(), ndim_(), ndindex_(), negative_(),
```

newaxis\_(), nextafter\_(), nonzero\_(), not\_equal\_(), nper\_(), npv\_(), number\_(),  
obj2sctype\_(), ogrid\_(), ones\_(), ones\_like\_(), outer\_(), packbits\_(),  
percentile\_(), pi\_(), piecewise\_(), place\_(), pmt\_(), poly\_(), poly1d\_(),  
polyadd\_(), polyder\_(), polydiv\_(), polyfit\_(), polyint\_(), polymul\_(), polysub\_(),  
polyval\_(), power\_(), ppmt\_(), prod\_(), product\_(), ptp\_(), put\_(), putmask\_(),  
pv\_(), r\_(), rad2deg\_(), radians\_(), rank\_(), rate\_(), ravel\_(), real\_(),  
real\_if\_close\_(), reciprocal\_(), record\_(), remainder\_(), repeat\_(), reshape\_(),  
resize\_(), restoredot\_(), right\_shift\_(), rint\_(), roll\_(), rollaxis\_(), roots\_(),  
rot90\_(), round\_(), round\_(), row\_stack\_(), s\_(), sctype2char\_(),  
searchsorted\_(), select\_(), setbufsize\_(), setdiff1d\_(), seterr\_(), setxor1d\_(),  
shape\_(), short\_(), sign\_(), signbit\_(), signedinteger\_(), sin\_(), sinc\_(),  
single\_(), singlecomplex\_(), sinh\_(), size\_(), sometrue\_(), sort\_(),  
sort\_complex\_(), spacing\_(), split\_(), sqrt\_(), square\_(), squeeze\_(), std\_(),  
str\_(), str\_(), subtract\_(), sum\_(), swapaxes\_(), take\_(), tan\_(), tanh\_(),  
tensordot\_(), tile\_(), trace\_(), transpose\_(), trapz\_(), tri\_(), tril\_(),  
tril\_indices\_(), tril\_indices\_from\_(), trim\_zeros\_(), triu\_(), triu\_indices\_(),  
triu\_indices\_from\_(), true\_divide\_(), trunc\_(), ubyte\_(), uint\_(), uint0\_(),  
uint16\_(), uint32\_(), uint64\_(), uint8\_(), uintc\_(), uintp\_(), ulonglong\_(),  
union1d\_(), unique\_(), unravel\_index\_(), unsignedinteger\_(), unwrap\_(), ushort\_(),  
vander\_(), var\_(), vdot\_(), vectorize\_(), vsplit\_(), vstack\_(), where\_(), who\_(),  
zeros\_(), zeros\_like\_(), fft\_(), linalg\_(), polynomial\_(), random\_()

A full discussion of Numpy is out of the scope of this document.



## Extensions

Extensions are optional add-ons that perform complex tasks in the background, while presenting a simplified, consistent interface to the scripts. This is where the real power of the apyengine comes through. Instead of having to know the gory details of all the Python modules a coder might want to use, they can just use the extensions. The messy bits are hidden under a clean interface.

Unlike the Modules, Extensions may or may not be available to a set of scripts. When apyshell is started, it may be passed an option to use a specific extension directory list (-e). Only the extensions in those directories are available to be loaded. Thus you can control what the scripts running under a given invocation of apyshell can do.

And also unlike Modules, Extensions may be unloaded. If you are finished with an Extension, and you want the resources back, simply call the “unloadExtension\_()” function with the name of the Extension.

Some Extensions, especially those that bring in data from the outside, have the option of a “handler”. This is simply a function, defined in your script, that gets called whenever data is available for processing. So instead of continuously polling a function, you can specify the handler and go about your other business. The handler will be called when data is ready.

The handlers generally run in the context of a thread running in the Extension. So it’s best to do as little as possible in the handler itself, and then put the data into a Queue for the main code to process when it can. This sort of event-driven architecture can be very flexible, and fast. Of course, you can just poll in a loop for your data also.

The following is a list of the currently-supplied Extensions. The sources are fully commented, and may be used as templates for building new ones.

## **fileext**

scripts/fileext.py

This extension provides some simple text file handling. It limits the file locations to a pre-set directory and below (the “file\_root” option).

To install:

```
loadExtension_('fileext')
```

To uninstall:

```
unloadExtension_('fileext')
```

This extension provides the following functions. Note that some are optional:

```
readLines_(filepath, handler=None, maxlines=0)
```

Reads lines from a text file (all or up to a specified count) . If the “handler” argument is present, each line (up to maxlines) is passed to the handler as it’s read. Otherwise, the text is accumulated in a buffer and passed back when it hits maxlines or EOF.

```
writeLines_(filepath, data, handler=None, maxlines=0)
```

Writes lines to a text file (all or up to a specified count) . If the “handler” argument is present, the handler functions is called for a line of text (up to maxlines), which is then written to the file.. Otherwise, the text in the data buffer is written line-by-line until it hits maxlines or the end of the buffer.

If the file exists, it’s overwritten.

```
appendLines_(filepath, data, handler=None, maxlines=0)
```

Writes lines to a text file (all or up to a specified count) . If the “handler” argument is present, the handler functions is called for a line of text (up to maxlines), which is then written to the file.. Otherwise, the text in the data buffer is written line-by-line until it hits maxlines or the end of the buffer.

If the file doesn’t exists, it’s created. Otherwise, lines are appended to the end of the file.

```
listFiles_(filepath='')
```

Returns a list of files and subdirectories, either in the file\_root, or a path **below** it.

There are some extension options defined in apyshell.py that modify this Extension:

|                                    |  |
|------------------------------------|--|
| 'file_root': '/opt/apyshell/files' | All file activity through this Extension happens in or under this path.  |
| 'read_only': False                 | If True, only the readLines_() and listFiles_() functions are installed. |
| 'list_files': True                 | If False, the listFiles_() function is not installed.                    |

Example:

Here's a simple sample script that doesn't use a handler:

```
r = loadExtension_('fileext')
l = listFiles_()
print('Files:', l)
n = readLines_('w.txt')
print(n)
```

Assuming that there's a single file in the file\_root directory named "w.txt", this is what the output would look like:

```
--> Files: ['w.txt']
--> line1
line2
line3
```

And here's a quick one with a handler:

```
r = loadExtension_('fileext')

# this is a handler - it gets each line as it
# is read.
def oneline(l):
    print(l, prefix='-->')

# pass each line through the handler
n = readLines_('w.txt', handler='oneline')
```

Produces:

```
--> line1
--> line2
--> line3
```

## ***flagext***

flagext.py

This extension provides a means for threads to synchronize with each other. It allows the script to create named "flags" that script elements running in different threads (such as handlers) can manipulate. A flag may be raised or lowered, and threads can wait for a flag to be raised. Flags may also be checked for state without waiting.

If multiple threads are waiting on a flag, they will all be released when it's raised.

This is really a wrapper around a set of Threading.Event() objects. The "flag" metaphore is easier to visualize, and the Extension handles all of the fussy bits of managing a bunch of Event objects.

Make the functions available to a script by adding:

To install:

```
loadExtension_('flagext')
```

To uninstall:

```
unloadExtension_('flagext')
```

This extension provides the following functions:

```
flag_add_(name)
```

This function creates a new flag and adds it's name to the table. The name must be unique, and it used to refer to the flag in the rest of the functions.

Returns True if the flag was created, False if there was an error.

```
flag_del_(name)
```

This function triggers any waiting listeners by raising the flag momentarily, then deleting the flag entry and it's underlying Event object.

Returns True if the flag was deleted, False if there was an error.

```
flag_raise_(name, toggle=False)
```

This function raises the flag, thus signaling any threads sitting in flag\_wait\_() to continue running. If toggle is False, the flag will remain in the raised state. If toggle is True, it will be lowered automatically after a very brief pause.

Returns True if the flag was raised, False if there was an error.

`flag_lower_(name)`

This function lowers a flag – setting it to a cleared state. Any thread calling `flag_wait_()` on this flag will then pause until it's raised (or timeout).

Returns True if the flag was lowered, False if there was an error.

`flag_israised_(name)`

This function returns the current state of a flag.

Returns True if the flag is currently raised, False if it's lowered, or there was an error.

`flag_wait_(name, timeout=1.0, **kwargs)`

This function waits until the specified flag is raised, or the timeout expires. This will pause execution of the thread it's called from. If the flag is in the raised state when `flag_wait_()` is called, it will return immediately. The timeout value is in seconds and fractional seconds.

The options that may be added (kwargs) are:

prelower:            If True, lower the flag **before** beginning to wait for it.

postlower:           If True, lower the flag **after** the wait returns, **if** it didn't timeout.

Returns True if the flag was raised before the timeout (or upon entry), False if the wait reached the timeout value, or there was an error.

`flag_list_()`

Returns a list of flag names, or any empty list if there are none.

## Example:

```
#
# flagdemo.apy
#
# This apyshell script demonstrates the flag extension. This shows
# the basic operation, but only in a single thread. Flags are really
# only useful when there are multiple threads in the script.
#
# Mark Anacker  closecrowd@pm.me
# -----

#
# Load the httpext.py extension - if this invocation of
# apyshell.py has it available in the designated extensions
# directory. By default, it would be.
#
e = loadExtension_('flagext')
if not e:
    print('Failed to load the flag extension!')
    exit_(1)

# create a named flag
r = flag_add_('fname')
print('Add flag:', r)

# check it's status
r = flag_israised_('fname')
print('Flag raised:', r)

# okay, now raise it
r = flag_raise_('fname')
print('Flag raise:', r)

r = flag_israised_('fname')
print('Flag raised:', r)

# wait up to 3 seconds for the flag to raise,
# then lower it on the way out. This should
# return True, since we just raised it.
r = flag_wait_('fname', 3.0, postlower=True)
print('Flag wait return 1:', r)

r = flag_israised_('fname')
print('Flag raised:', r)

# this time, wait 3 seconds for the flag. This
# will return False, since the flag will stay
# lowered.
r = flag_wait_('fname', 3.0)
print('Flag wait return 2:', r)

# now clean up
flag_del_('fname')
```

## ***utilext***

utilext.py

This extension provides an assortment of useful functions that don't fit in elsewhere.

To install:

```
loadExtension_('utilext')
```

To uninstall:

```
unloadExtension_('utilext')
```

This extension provides the following functions. Note that some are optional:

```
input_(prompt=None, default=None, **kwargs)
```

This function will (optionally) print a prompt on the console, then wait for (and return) whatever the user types in. A default value may be set to be returned if nothing was entered. A timeout can also be set, either returning a default value or raising an exception if the timeout expires without a console entry.

The options that may be added (kwargs) are:

timeout : Input timeout in seconds. The default is 0 (no timeout).

todef : Default value to return if the timeout expires.

toraize : If True, raise an Exception when the timeout expires instead of returning the default value.

```
getenv_(name)
```

This function returns the value of an item in the host application's environment. Since this might be unsafe, it has to be specifically enabled by the host application in the extension options.

```
system_(cmd)
```

This function simply runs whatever string is passed to it in the host environment. Useful for debugging or calling external applications, it has to be deliberately enabled by the host application. This is rather dangerous – you should probably set the default in apyshell.py to False unless you really need it.

There are some extension options defined in apyshell.py that modify this Extension:

|                     |  |
|---------------------|--|
| 'allow_system':True | Install the system_() function if True |
| 'allow_getenv':True | Install the getenv_() function if True |

Example:

demoinput.apy

```
# load the extension
loadExtension_('utiltext')

# prompt the user to enter something. If they don't within 5 seconds,
# the string "time!" will be returned
try:
    f = input_('type something ', '--', timeout=5, todef='time!', toraise=False)
    print('you typed:', f)
except Exception as e:
    print('exception:', str(e), prefix=None)
```

Here we enter a line on the console:

```
type something okay
--> you typed: okay
```

And the text we typed was returned. Here we don't (the toraise option is False):

```
type something --> you typed: time!
```

The default value was returned. When toraise is True and the timeout expires:

```
type something exception: Error running function call 'input_' with args ['type something ',
'--'] and kwargs {'timeout': 5,
'toraise': True, 'todef': 'time!'}: Timed out at line 16
```

Like another well-known scripting language, there's more than one way to do something.



## ***queueext***

queueext.py

This extension provides thread-safe queues for communicating between threads (and callback handlers). It has all the queue management functions anyone should need.

Queues are referenced by name (set in the `queue_open_()` function), and may be either a classic First-In-First-Out queue, or a Last-In-First-Out stack. These queues are an excellent way to pass data from an event-driven handler function to a main processing loop.

To install:

```
loadExtension_('utilext')
```

To uninstall:

```
unloadExtension_('utilext')
```

This extension provides the following functions:

```
queue_open_(name, **kwargs)
```

Creates a queue referenced by “name” (if there isn’t already a queue with that name). This queue will initially be empty.

The option that may be added (kwargs) is:

type : Either ‘fifo’ for a regular queue, or ‘lifo’ for a stack. The default is ‘fifo’.

It will return True if the queue was created, False if there was an error.

```
queue_close_(name)
```

Empties the named queue (if it exists), and deletes it. Any script elements (handlers, tasks, etc.) that are waiting on a `queue_get_()` will return immediately.

It will return True if the queue was removed, False if there was an error.

```
queue_put_(name, value, **kwargs)
```

Adds the given value to the queue (tail (fifo) or head (lifo)). If value is None, this function simply returns False.

The options that may be added (kwargs) are:

**block :** If True, block until there is room in the queue to add the value, **or** the timeout expires, **or** the queue is closed.

**timeout:** The number of seconds to wait for a blocking put to succeed before returning False. The default is 0, which means block forever (or the queue is closed).

It will return True if the value was added to the queue, False if there was an error.

`queue_get_(name, **kwargs)`

Gets an item from the queue. A 'fifo' queue returns the item at the HEAD of the queue. A 'lifo' type will return the item at the END of the queue.

The get operation may be either blocking or non-blocking. If the block option in kwargs is False, the operation will return immediately. If the queue was empty, the return will be None.

If block is True (default) and the queue is empty, the get operation will be retried at 1-second intervals until either: an item is added to the queue, the timeout count is reached, or the queue is closed. A timeout of 0 will retry until either success or close.

The options that may be added (kwargs) are:

**block :** If True, block until there is an item in the queue to return, **or** the timeout expires, **or** the queue is closed.

**timeout:** The number of seconds to wait for a blocking get to succeed before returning False. The default is 0, which means block forever (or the queue is closed).

It will return the next item from the queue, or None if:

- the queue is empty and block==False,
- block == True and the timeout expired, or
- the queue was closed().

`queue_clear_(name)`

Removes all the items in a queue.

Returns True if the queue was cleared, False if there was an error.

`queue_len_(name)`

Returns the number of items in the named queue.

It will return 0 if there was an error.

`queue_isempty_(name)`

Returns True if the queue is empty.

`queue_list_()`

Returns a list of the currently-open queues. If there are no queues, it returns an empty list.

It will return None if there was an error.

## ***mqtttext***

mqtttext.py

This extension implements a client for the MQTT pub/sub protocol. It can handle multiple connections to MQTT brokers, publish messages to topics, and subscribe to topics. Incoming messages on subscribed topics may be delivered by polling, or by handler callbacks.

Some knowledge of MQTT and it's operation is helpful – see these links:

<https://mqtt.org/>  
<https://pypi.org/project/paho-mqtt/>  
<https://github.com/eclipse/paho.mqtt.python>

Note: This Extension requires that the “paho.mqtt.client” module be installed on the host system.

The link to a broker is represented by a connection name. Each connection is separate from the others, and each may have multiple topics subscribed to it. Secure connections using TLS are supported.

Before any messages come in, you have to subscribe to one or more topics on the broker. You may read the incoming messages by calling `mqtt_readmsg_()` in a loop. This will deliver the payloads for all subscribed topics, and is the easier to set up. You can also specify handler functions to be called when a message comes in. There can be a handler for each topic, and/or a general one for topics that don't have a specific handler. If you define a handler (general or specific), then it will take precedence over `mqtt_read_msg_()`. Handlers will be passed a single argument – a tuple with the same data as returned by `mqtt_read_msg_()`: (message payload, topic, qos, retain flag, and mqttname).

To install:

```
loadExtension_('mqtttext')
```

To uninstall:

```
unloadExtension_('mqtttext')
```

This extension provides the following functions:

```
mqtt_connect_(cname, **kwargs)
```

Create a named connection to an MQTT broker. The connection name must be unique, and is used to refer to this connection in the rest of the functions.

The options that may be added (kwargs) are:

|              |   |
|--------------|---|
| name:        | A unique name for this connection – the mqttname (optional)                               |
| broker:      | The hostname or IP address of the broker (required)                                       |
| port:        | The port to connect to the broker. (default is 1883)                                      |
| clientid:    | A unique ID for this client connection. If not specified, a random one will be generated. |
| timeout:     | Connection timeout in seconds(default = 10)   |
| tos:         | MQTT Type Of Service (default = 0)  |
| reconnect:   | If True, automatically reconnect if the link to the broker is lost                        |
| keepalive:   | Keepalive interval (default = 30 seconds)   |
| username:    | Client username (optional)  |
| password:    | Client password (optional)  |
| tlscafile:   | Client-side CA file   |
| tlscertfile: | Client-side TLS certificate   |
| tlskeyfile:  | Client-side TLS key file  |
| tlsvers:     | TLS Version to use  |
| tlsinsecure: | Insecure mode (False)   |

handler: A script function incoming messages not otherwise sent to per-sub handlers (optional)

Depending on the network, it may take a few seconds to fully connect to the broker. This is an asynchronous function – it returns right away. You may call `mqtt_isrunning_()` to check if the connection is ready or not.

`mqtt_disconnect_(cname)`

Disconnect a named connection from the broker and release it's resources. No further communications will occur under this name.

`mqtt_isrunning_(cname)`

Returns True if the named connection is fully hooked into the broker, and will accept messages.

`mqtt_subscribe_(cname, topic, handler=None, qos=0)`

Starts receiving messages from the broker on the specified topic. If a handler is given, then messages will be diverted to that handler instead of the `mqtt_readmsg_()` function. MQTT wildcards are supported (+ and #).

`mqtt_unsubscribe_(cname, topic)`

Stops the flow of incoming messages on the specified topic.

`mqtt_waiting_(cname)`

Returns True if there are messages waiting to be read on this connections.

`mqtt_readmsg_(cname, blocking=True, timeout=1)`

This function returns the next available message from any topic that doesn't have a handler attached to it's subscription. Incoming messages without a handler are added to a FIFO queue, and this function will return the first available item.

If blocking is True, the function will wait until a message is available, or the timeout is exhausted. In that case, the return value will be None.

The return value is a tuple consisting of: (message payload, topic, qos, retain flag, and mqttname). All subscribed topics in the connection that do not have handlers will come here.

`mqtt_sendmsg_(cname, dest, data, qos=0, retain=False)`

This function sends a message to the topic or topics via this connection. The "dest" parameter may be a string with a single topic name, a string with a representation of a list, or an actual list of topics. For example:

```
'onetopic'  
['onetopic,twotopic']  
['onetopic', 'twotopic']
```

The last two versions are effectively the same. The "qos" value must range from 0-2 (see the MQTT specs for the meanings), and "Retain" is the MQTT message retain flag. Both are optional.

The connection does **not** need to be subscribed to a topic (or any topics) to send messages to any topic.

`mqtt_list_()`

Returns a list of opened connections, or any empty list if there are none.

Examples:

This is a very simple little script that grabs the date and time every 10 seconds, and publishes it to a topic named “clock”. It illustrates sending data to a topic:

```
install_('time')
e = loadExtension_('mqtttext')

cname = 'mqclock'

bip = 'mqttb1'

# connect to the broker
m = mqtt_connect_(cname, broker=bip, name='timepub')
# wait for it to finish
sleep_(1)

# loop forever
while True:
    # get a time string
    ts = asctime_()
    # send it to the 'clock' topic
    rv = mqtt_sendmsg_(cname, 'clock', ts)
    # wait a bit
    sleep_(10)

# clean shutdown
mqtt_disconnect_(cname)
```

A companion script that subscribes to the ‘clock’ topic and prints the time, using the default polling method:

```
install_('time')
e = loadExtension_('mqtttext')

cname = 'mqclockrecv'

bip = 'mqttb1'

# connect to the broker
m = mqtt_connect_(cname, broker=bip, name='timesub')
# wait for it to finish
sleep_(1)

mqtt_subscribe_(cname, 'clock')

# loop forever
while True:
    msg = mqtt_readmsg_(cname, blocking=True, timeout=30)
    if msg != None:
        (payl, top, qos, retain, sender) = msg
        print(payl)
```

See the scripts distributed with apyshell for more examples of the mqtt Extension.

## ***redisext***

redisext.py

This extension provides a client connection to a redis in-memory cache. Not all redis functions are available (there are a *lot* of them), but a lot of the useful ones are included.

Familiarity with redis is helpful – see these links:

<https://redis.io/commands/>  
<https://github.com/redis/redis-py>

Note: This Extension requires that the “redis” module be installed on the host system.

To install:

```
loadExtension_('redisext')
```

To uninstall:

```
unloadExtension_('redisext')
```

This extension provides the following functions:

```
redis_connect_(cname, host='127.0.0.1', port=6379, **kwargs)
```

This function creates a named connection to a redis server. You may specify the hostname or IP address of the server, as well as a port (with 6379 as the default).

The options that may be added (kwargs) are:

|                   |  |
|-------------------|--|
| db :              | redis db index (default is 0)                    |
| decode_responses: | If True, return strings. If False, return bytes. |

These are not yet fully implemented:

```
username:  
password:  
retry_on_timeout:  
health_check_interval:
```

```
redis_disconnect_(cname)
```

Disconnects the named connection from the server and cleans up resources.



`redis_list_()`

Returns a list of active connections, or an empty list if there are none.

`redis_cmd_(cname, *args)`

Submits a raw `redis_cli` command directly to the server. This is a way to use commands that do not have corresponding functions exposed in this Extension. Note that this could be a security hazard, so it has to be enabled by the host application via an option setting.

*The following functions map directly to `redis_cli` commands:*

`redis_set_(cname, key, value)`

Set the value at key name to value

`redis_get_(cname, key)`

Return the value at key, or None if the key doesn't exist

`redis_del_(cname, key)`

Delete one or more keys specified by key

`redis_incr_(cname, key, val=1)`

Increments the value of key by val. If no key exists, the value will be initialized as val

`redis_decr_(cname, key, val=1)`

Decrements the value of key by val. If no key exists, the value will be initialized as 0 - val

`redis_hset_(cname, hashname, key, value='')`

Set key to value within hash hashname

`redis_hmset_(cname, hashname, map)`

Set key to value within hash hashname for each corresponding key and value from the mapping dict.

`redis_hget_(cname, hashname, key)`

Return the value of key within the hash name

```
redis_hdel_(cname, hashname, key)
```

Delete keys from hash hashname

```
redis_hkeys_(cname, hashname)
```

Return the list of keys within hash hashname

```
redis_hvals_(cname, hashname)
```

Return the list of values within hash hashname

There is an extension option defined in apyshell.py that modifies this Extension:

```
'allow_redis_cmds':True          Install the redis_cmd_() function.
```

Example:

This is a script that subscribes to an MQTT topic, and waits for temperature messages from an IOT device. It converts the C readings to F, and puts them in a hash in the Redis server. This script is included in the distribution as `mqttdemo_redis.apy`

```
#
# mqttdemo_redis.apy
#
# This apyshell script demonstrates receiving and processing messages
# published to an MQTT broker, and storing the values in a Redis cache.
#
# It connects to a broker running on the local machine, and listens
# for messages send by a Cricket IOT module. The temperature values
# from the Cricket are converted to F, then stored in a Redis hashset.
#
# Mark Anacker  closecrowd@pm.me
# -----

#install_('time')

#
# Load the mqtttext.py extension - if this invocation of
# apyshell.py has it available in the designated extensions
# directory. By default, it would be.
#
e = loadExtension_('mqtttext')
if not e:
    print('Failed to load the mqtt extension!')
    exit_(1)

# now load the redisext.py extension
e = loadExtension_('redisext')
if not e:
    print('Failed to load the redis extension!')
    exit_(1)

# Every mqtt broker connection has a name.
cname = 'mqttdemo'

# as does a redis connection
rname = 'redisdemo'

# This is the topic string for all messages from this device
alltopic = 'link/iot/c2/#'

# This is the IP address of our broker.
brokerip = 'mqttb1'

# This is the IP of a handy redis server
cacheip = 'mqttb1'

# Crickets report temp in C (they're British). Convert
# to proper F units....
def ctof(val):
    return (val * 1.8) + 32
```

```

# Enough prep - let's start processing data

# Connect to the cache using our connection name (rname).
r = redis_connect_(rname, cacheip)
if not r:
    print('Failed to connect to redis!')
    exit_(2)

# Connect to the broker, using our connection name (cname)
# as the client name also. This is just for convenience -
# you would probably used a meaningful name for the client
# here (name=)
m = mqtt_connect_(cname, broker=brokerip, name=cname)
if not m:
    print('Failed to connect to mqtt!')
    exit_(2)

print('connected to', brokerip, 'as', cname)

mqtt_subscribe_(cname, alltopic)
print('subscribed to', alltopic)

#
# Poll for messages. Note that *all* messages that this
# connection has subscribed to will come through here. If you have
# multiple topics subscribed, you get to sort them out yourself.
#
# This is one of the ways that we can get messages from the topics
# we subscribe to. As someone once said: "there is another...".
# Please see the other mqttdemo scripts to see how per-topic
# callbacks work.
#
# Incoming messages are put in a queue - mqtt_readmsg_() grabs the
# next available message (if any). There's a timeout if nothing is
# there yet.
#
while True:
    # read the next available message
    msg = mqtt_readmsg_(cname, blocking=True, timeout=5)
    # got something
    if msg != None:
        # print the entire message so you can see it
        print('msg:', msg)
        # the message is a tuple with the following elements:
        # pay - the message payload (decoded utf-8)
        # top - the complete topic of this message
        # qos - the QOS the message was published with
        # rtain - the message retain flag
        # connname - the connection name this message came over
        (pay, top, qos, rtain, connname) = msg

        # split the topic
        cols = split(top, '/', 2)
        # we only want part of it
        (a, b, label) = cols
        # if this is a temperature value:
        if label == 'c2/temp' or label == 'c2/io3_ds18b20':
            tempf = ctof(float(pay))
            print('    **', label, tempf)
            # now update a redis hashset named 'temps' with an entry
            # having a key of the label, and a value of the computed

```

```

    # temperature.
    rv = redis_hset_(rname, 'temps', label, tempf)

# cleanly disconnect from the broker
mqtt_disconnect_()

# and redis
redis_disconnect_(rname)

exit_(0)

#
# This is what the console output would look like:
#
# --> connected to 127.0.0.1 as mqttdemo
# --> subscribed to link/iot/c2/#
# --> msg: ('c2', 'link/iot/c2/device_name', 0, 1, 'mqttdemo')
# --> msg: ('D7923E5656', 'link/iot/c2/device_sn', 0, 1, 'mqttdemo')
# --> msg: ('215235', 'link/iot/c2/hwc_wake_up', 0, 1, 'mqttdemo')
# --> msg: ('215205', 'link/iot/c2/hwc_wifi_enabled', 0, 1, 'mqttdemo')
# --> msg: ('206994', 'link/iot/c2/hwc_message_sent', 0, 1, 'mqttdemo')
# --> msg: ('10.80', 'link/iot/c2/temp', 0, 1, 'mqttdemo')
# --> ** c2/temp 51.44
# --> msg: ('10.56', 'link/iot/c2/io3_ds18b20', 0, 1, 'mqttdemo')
# --> ** c2/io3_ds18b20 51.008
# --> msg: ('1', 'link/iot/c2/io3', 0, 1, 'mqttdemo')
# --> msg: ('3.14', 'link/iot/c2/batt_voltage', 0, 1, 'mqttdemo')
# --> msg: ('230', 'link/iot/c2/batt', 0, 1, 'mqttdemo')
# --> msg: ('0', 'link/iot/c2/io1_wake_up', 0, 1, 'mqttdemo')
# --> msg: ('1', 'link/iot/c2/rtc_wake_up', 0, 1, 'mqttdemo')

#
# and what shows up in the redis server:
#
# > redis-cli -h 127.0.0.1 hgetall temps
# 1) "c2/temp"
# 2) "51.44"
# 3) "c2/io3_ds18b20"
# 4) "51.008"
# >
#

```

## **sqliteext**

sqliteext.py

This extension allows a script to store and retrieve data from a sqlite3 database. Some basic knowledge of SQLite3 and SQL is helpful when using this extension - ee this link:

<https://docs.python.org/3/library/sqlite3.html>

Note: This Extension requires that the “sqlite3” module be installed on the host system.

To install:

```
loadExtension_('sqliteext')
```

To uninstall:

```
unloadExtension_('sqliteext')
```

This extension provides the following functions:

```
sql_open_(cname, dbname, **kwargs)
```

Open a connection to a sqlite3 database file, creating the files if it doesn't exist. The connection name and the database filename do not have to be the same.

A check is made to make sure the database filename isn't already in use by another connection. It's probably not a good idea to have the same file accessed by multiple connections simultaneously. That's not the same as calling this extension from multiple threads (which is supported).

The options that may be added (kwargs) are:

autocommit: If True, update the file after every change. Default=True.  
check\_same\_thread: If True, restrict callers to a single thread. Default=False.

```
sql_close_(cname)
```

Close an open db connection and remove the connection from the table.

```
sql_execute_(cname, sql, *args, **kwargs)
```

Execute an SQL statement in an open connection. The SQL statement may have positional parameters marked with '?', which are filled in from the \*args parameter. Any options in \*\*kwargs are passed to the sqlite3 module.

This function returns a Cursor object, which may be passed to `sql_cursor_fetch_()` to retrieve the data rows.

`sql_commit_(cname)`

Commit pending updates to the database. If `autocommit` is `True`, this function has no effect.

`sql_rollback_(cname)`

Rollback pending changes.

If `autocommit` is `False`, updates to the database are held in a buffer until `sql_commit_()` is called. This function clears that buffer, effectively reverting changes back to the last `sql_commit_()`. If `autocommit` is `True`, this function has no effect.

`sql_changes_(cname)`

Returns the number of changes to the database since it was last opened.

`sql_cursor_fetch_(cname, cursor, count=0)`

Return one or many rows from the supplied cursor (returned by `sql_execute_()`). The “count=” option determines how many rows to return:

-1 = get the next row as a tuple.

0 = get **all** the rows as a list of tuples.

>0 = get **all** rows <n> at a time as a list of tuples.

`sql_list_()`

Returns a list of opened connections, or any empty list if there are none.

Example:

This is a simple script named `"sqldemo.apy"` (included in the distribution) that opens a database and writes some lines to it, then retrieves them back out:

```
#
# sqldemo.apy
#
# This script opens (or creates) a sqllite3 database and
# writes some rows to it. The directory location of the
# database file itself is set by apyshell - the script sets
# the filename.
#
# Mark Anacker <closecrowd@pm.me>
# -----

# make the time commands available
install_('time')

#
# Load the sqliteext.py extension - if this invocation of
# apyshell.py has it available in the designated extensions
# directory. By default, it would be.
#
e = loadExtension_('sqliteext')
if not e:
    print('Failed to load the sqllite extension!')
    exit_(1)

# a name for the connection to this database
sqlconn = 'connname'

# open (or create) the database named 'demodb' at the location
# set by apyshell ('sql_root' option), with the extension also
# set by apyshell ('sql_ext' option).

rv = sql_open_(sqlconn, 'demodb', autocommit=True, check_same_thread=False)
if not rv:
    print('Failed to open the database!')
    exit_(2)

# we're going to use a table called "demotime"
# see if it's in the db:
res = sql_execute_(sqlconn, "SELECT name FROM sqlite_master where name='demotime'")
# nope - we have to create it
if res.fetchone() == None:
    print('creating our table')
    sql_execute_(sqlconn, "create table demotime(id, timestamp, data)")

print('running')

# let's add some valuable(?) data....
for cnt in range(1, 11):
    print(cnt)

    # add the row
    sql_execute_(sqlconn, "insert into demotime(id, timestamp) values(?,?);", cnt,
asctime_(localtime_()))
```



```

# delay 2 seconds so the timestamp advances
sleep_(2)

# print how many updates we made to the db
print('changes:', sql_changes_(sqlconn))

#
# Now we demonstrate reading that data OUT of the database:
#

# execute a query to get the data we put ion
cur = sql_execute_(sqlconn, "select * from demotime;")

# and pull all the rows out into a list[] of tuples()
retlist = sql_cursor_fetch_(sqlconn, cur, count=0)
# if we got any, that is
if retlist:
    for row in retlist:
        print(row)

# all done - close up
rv = sql_close_(sqlconn)

exit_(0)

```

## ***tdicttext***

tdicttext.py

This extension provides thread-safe, named dictionaries (key,value). Python's built-in dict objects are **\*mostly\*** atomic (and therefore thread-safe), but not **\*always\***. And not every operation is guaranteed to be safe. Scripts in apyshell may make extensive use of threads, so an assured safe dict is needed.

Each named tdict has it's own lock, so they are relatively independent once created.

See also the companion tlist extension.

To install:

```
loadExtension_('tdicttext')
```

To uninstall:

```
unloadExtension_('tdicttext')
```

This extension provides the following functions:

```
tdict_open_(cname)
```

Creates a thread-safe dict object attached to the specified name.

```
tdict_close_(cname)
```

Clears and removes the specific tdict.

```
tdict_put_(cname, key, value)
```

Adds a new value indexed by the key to the dict, or replaces an existing value with the new one.

```
tdict_update_(cname, value)
```

Merges the entire contents of an existing dict object (value) into the named tdict.

```
tdict_get_(cname, key, value=None)
```

Retrieves an item indexed by the key from the dict, or returns a default value if the key isn't found.

```
tdict_pop_(cname, key, value)
```

Retrieves an item indexed by the key from the dict, or returns a default value if the key isn't found. Removes the item from the dict if the key was found.

`tdict_del_(cname, key)`

Removes an item indexed by the key from the dict.

`tdict_clear_(cname)`

Removes all items from the named dict.

`tdict_keys_(cname)`

Returns a list with the keys in the named dict.

`tdict_items_(cname)`

Returns a list of every item in the dict, in the form of a tuple with (key,value) for each.

`tdict_len_(cname)`

Returns the number of items currently in the tdict.

`tdict_copy_(cname)`

Returns a standard Python dict object with a shallow copy of the contents of the specified tdict.

`tdict_list_()`

Returns a list with the names of all current dictionaries.

Example:

This is a simple script named `"tdictdemo.apy"` (included in the distribution) that demonstrates some basic operations.

```
#
# tdictdemo.apy
#
# This script demos creating and using a thread-safe dict
# from the tdict Extension. All of the operations are
# protected by locks to make them thread-safe.
#
# Mark Anacker <closecrowd@pm.me>
# -----

# make the time commands available
install_('time')

#
# Load the tdictext.py extension - if this invocation of
# apyshell.py has it available in the designated extensions
# directory. By default, it would be.
#
e = loadExtension_('tdictext')
if not e:
    print('Failed to load the tdict extension!')
    exit_(1)

# create a dictionary
td = tdict_open_('mydict')

# put some data in it
print('filling')
for n in range(0,20):
    tdict_put_('mydict', str(n), asctime_(localtime_()))
    # we delay 1 second so the timestamp changes
    sleep_(1)

# and get it back out
print('dumping')

print('there are',tdict_len_('mydict'),'items')
print('')
print('items in mydict:',tdict_items_('mydict'))
print('')
print('all keyskeys:',tdict_keys_('mydict'))

# make a standard Python dict with a copy of the
# items in the tdict.
pd = tdict_copy_('mydict')
print('created Python dict:', type(pd))

# open a new tdict
b = tdict_open_('newdict')
# if it's opened
if b:
    # mass-update it with items from the old one
    # this essentially makes a Python dict, then loads that
    # copy into the tdict.
    tdict_update_('newdict', tdict_copy_('mydict'))
```

```
    print('items in newdict:',tdict_items_('newdict'))
    # and close it
    tdict_close_('newdict')

# close the original dict
tdict_close_('mydict')
```

httpext  
httpext.py

This extension provides HTTP(s) client functions to the scripts. It can perform GET and PUT requests, using one of two external modules (requests or http.client). If you are using the requests mode (1), you can also issue any HTTP request type (GET, OPTIONS, HEAD, POST, PUT, PATCH, or DELETE).

Note: This Extension requires that either the “requests” **or** “http.client” modules (or both) be installed on the host system.

To install:

```
loadExtension_('httpext')
```

To uninstall:

```
unloadExtension_('httpext')
```

This extension provides the following functions:

```
http_modes_()
```

Returns a tuple consisting of the list[] of available client modes, and the default mode selected by the extension. There are currently two client modes: 1 uses the requests module, and 2 uses the http.client module. This extension tries to use mode 1, but will use mode 2 if the requests module fails to import.

Each request may override the default and choose which mode it wants, if that mode is available.

```
http_get_(url, **kwargs)
```

Sends an HTTP or HTTPS GET to the specified URL, using one of the client modes. The mode is either the default set in \_\_init\_\_() above, or specified by the 'client=' option.

The options that may be added (kwargs) are:

|          |   |
|----------|---|
| client:  | The client mode (1 or 2) to use.  |
| headers: | A dict of HTTP headers to use.  |
| simple:  | Returns only the retrieved text.  |
| timeout: | Request timeout in seconds.   |
| cert:    | TLS certificate - either a String with just the client cert, or a tuple with the cert and keyfile: (cert, keyfile). |
| verify:  | Verify the server hostname.   |

Other options are passed to the requests or http.client modules.

```
http_put_(url, **kwargs)
```

Sends an HTTP or HTTPS PUT to the specified URL, using one of the client modes. The mode is either the default set in `__init__()` above, or specified by the 'client=' option.

The data to send in the body of the PUT is set by the 'data=' option.

The options that may be added (kwargs) are:

|          |   |
|----------|---|
| client:  | The client mode (1 or 2) to use.  |
| data:    | The data to send to the server  |
| headers: | A dict of HTTP headers to use.  |
| timeout: | Request timeout in seconds.   |
| cert:    | TLS certificate - either a String with just the client cert, or a tuple with the cert and keyfile: (cert, keyfile). |
| verify:  | Verify the server hostname.   |

```
http_request_(method, url, **kwargs)
```

This is a thin wrapper over the requests method of the requests module. As such, it's only available if the requests import succeeded.

Options (kwargs) are passed to the requests module.

## Example:

```
#
# httpdemo.apy
#
# This apyshell script demonstrates the http client extension.
#
# Mark Anacker  closecrowd@pm.me
# -----

# install the time module so we can sleep_()
install_('time')

# install the JSON module to parse returns
install_('json')

#
# Load the httpext.py extension - if this invocation of
# apyshell.py has it available in the designated extensions
# directory. By default, it would be.
#
e = loadExtension_('httpext')
if not e:
    print('Failed to load the http extension!')
    exit_(1)

#
# There are possibly 2 client modes available:
# 1 - Python's requests module
# 2 - Python's http.client module
#
# If both are installed, the default is to use requests (1), since
# it's more capable. This is how your script can find out what
# modes are available:
#

modes = http_modes_()
print('Client modes available:', modes[0], 'and default:', modes[1])

#
# httpext supports ONLY http and https requests. This is what
# happens when someone tries another scheme:
#

res = http_get_('FILE:///etc/hosts')
print('FILE:// results:', res)

#
# Set up some values for our next operations
#

# Let's get the Useless Fact of the Day
URL = 'https://uselessfacts.jsph.pl/api/v2/facts/today'

# This is the header that will be sent with each request, instead of the default
heads = {"Content-type": "text/plain; charset=UTF-8",
        "Accept": "text/plain", "Connection": "close",
        "Accept-Language": "en-US,en;q=0.5",
```



```

        "Upgrade-Insecure-Requests" : "1",
        "DNT" : "1",
        "User-Agent": "Opera/9.80 (Android 2.3.4; Linux; Opera Mobi/build-1107180945; U;
en-GB) Presto/2.8.149 Version/11.10" }

#
# Practice some GETS...
#

print('Client mode 1, simple=True')
r = http_get_(URL,client=1, headers=heads, simple=True)
print(str(r),prefix=None)
print(prefix=None)

sleep_(2)
print('-----', prefix=None)

print('Client mode 1, simple=False')
r = http_get_(URL,client=1, headers=heads, simple=False)
print(str(r),prefix=None)
print(prefix=None)

sleep_(2)
print('-----', prefix=None)

print('Client mode 2, simple=True')
r = http_get_(URL,client=2, headers=heads, simple=True)
print(str(r),prefix=None)
print(prefix=None)

sleep_(2)
print('-----', prefix=None)

print('Client mode 2, simple=False')
r = http_get_(URL,client=2, headers=heads, simple=False)
print(str(r),prefix=None)
print(prefix=None)

sleep_(2)
print('-----', prefix=None)

#
# Some other methods
#

# if we have mode 1 available
if modes[1] == 1:

    print('Request - HEAD')
    r = http_request_('HEAD', 'https://uselessfacts.jsph.pl/', headers=heads)
    print(str(r),prefix=None)
    print(prefix=None)

```

The output of this script looks like this:

```

--> Client modes available: [1, 2] and default: 1
--> FILE:// results: (998, 'http_get_() invalid scheme: file', None)
--> Client mode 1, simple=True
> Butterflies taste with their hind feet.

```

```
Source: [djtech.net](http://www.djtech.net/humor/useless_facts.htm)
Via: [uselessfacts]
(https://uselessfacts.jsph.pl/api/v2/facts/54540d7fadd6c53ca4f77d645b3dd752)
```

```
-----
--> Client mode 1, simple=False
(200, '> Butterflies taste with their hind feet.\n\nSource: [djtech.net]
(http://www.djtech.net/humor/useless_facts.htm)\nVia:
[uselessfacts](https://uselessfacts.jsph.pl/api/v2/facts/54540d7fadd6c53ca4f77d645b3dd752)',
{'_content_consumed': True, 'reason': 'OK', 'url': 'https://uselessfacts.jsph.pl/api/v2/facts/today', 'connection':
<requests.adapters.HTTPAdapter object at
0x7fae22d77c50>, 'status_code': 200, 'cookies': <RequestsCookieJar[]>, 'headers': {'Content-
Length': '206', 'Access-Control-
Allow-Origin': '*', 'Content-Type': 'text/plain; charset=UTF-8', 'Access-Control-Allow-
Methods': 'GET, POST, PUT, PATCH, DELETE, OPTIONS', 'Access-Control-Allow-Headers': 'Accept, Content-Type, Content-Length, Accept-
Encoding, Authorization', 'Connec
tion': 'close', 'Server': 'nginx', 'Date': 'Thu, 14 Dec 2023 06:36:29 GMT'}, 'elapsed':
datetime.timedelta(0, 0, 673328), 're
quest': <PreparedRequest [GET]>, '_next': None, '_content': b'> Butterflies taste with their
hind feet.\n\nSource: [djtech.ne
t](http://www.djtech.net/humor/useless_facts.htm)\nVia: [uselessfacts]
(https://uselessfacts.jsph.pl/api/v2/facts/54540d7fadd6
c53ca4f77d645b3dd752)', 'history': [], 'encoding': 'UTF-8', 'raw':
<urllib3.response.HTTPResponse object at 0x7fae22a4ba90>})
```

```
-----
--> Client mode 2, simple=True
{"id": "54540d7fadd6c53ca4f77d645b3dd752", "text": "Butterflies taste with their hind
feet.", "source": "djtech.net", "source_url":
"http://www.djtech.net/humor/useless_facts.htm", "language": "en", "permalink": "https://useless
facts.jsph.pl/api/v2/facts/54540d
7fadd6c53ca4f77d645b3dd752"}
```

```
-----
--> Client mode 2, simple=False
(200, '{"id": "54540d7fadd6c53ca4f77d645b3dd752", "text": "Butterflies taste with their hind
feet.", "source": "djtech.net", "sourc
e_url": "http://www.djtech.net/humor/useless_facts.htm", "language": "en", "permalink": "https://
uselessfacts.jsph.pl/api/v2/facts
/54540d7fadd6c53ca4f77d645b3dd752"}\n', {'fp': None, 'code': 200, 'reason': 'OK',
'will_close': False, 'status': 200, 'chunke
d': False, 'headers': 'Access-Control-Allow-Headers: Accept, Content-Type, Content-Length,
Accept-Encoding, Authorization\nAc
cess-Control-Allow-Methods: GET, POST, PUT, PATCH, DELETE, OPTIONS\nAccess-Control-Allow-
Origin: *\nContent-Length: 279\nCont
ent-Type: application/json; charset=UTF-8\nDate: Thu, 14 Dec 2023 06:36:35 GMT\nServer:
nginx\n\n', '__IOBase_closed': True,
'chunk_left': 'UNKNOWN', 'msg': 'Access-Control-Allow-Headers: Accept, Content-Type,
Content-Length, Accept-Encoding, Authori
zation\nAccess-Control-Allow-Methods: GET, POST, PUT, PATCH, DELETE, OPTIONS\nAccess-
Control-Allow-Origin: *\nContent-Length:
279\nContent-Type: application/json; charset=UTF-8\nDate: Thu, 14 Dec 2023 06:36:35
GMT\nServer: nginx\n\n', 'length': 0, 'v
ersion': 11, '_method': 'GET', 'debuglevel': 0})
```

```
-----
--> Request - HEAD
(405, '', {'_content_consumed': True, 'reason': 'Method Not Allowed', 'url':
```

```
'https://uselessfacts.jsph.pl/', 'connection': <
requests.adapters.HTTPAdapter object at 0x7fae22d816a0>, 'status_code': 405, 'cookies':
<RequestsCookieJar[]>, 'headers': {'C
onnection': 'close', 'Server': 'nginx', 'Date': 'Thu, 14 Dec 2023 06:36:37 GMT'}, 'elapsed':
datetime.timedelta(0, 0, 678454)
, 'request': <PreparedRequest [HEAD]>, '_next': None, '_content': b'', 'history': [],
'encoding': None, 'raw': <urllib3.respo
nse.HTTPResponse object at 0x7fae22a4b710>}}
```