MULTITHREADED PROGRAMMING

Running several threads is similar to running several different programs concurrently, but with the following benefits-

- Multiple threads within a process share the same data space with the main thread and can therefore share information or communicate with each other more easily than if they were separate processes.
- Threads are sometimes called light-weight processes and they do not require much memory overhead; they are cheaper than processes.

A thread has a beginning, an execution sequence, and a conclusion. It has an instruction pointer that keeps track of where within its context is it currently running.

- It can be pre-empted (interrupted).
- It can temporarily be put on hold (also known as sleeping) while other threads are running - this is called yielding.

There are two different kind of threads-

- kernel thread
- user thread

Kernel Threads are a part of the operating system, while the User-space threads are not implemented in the kernel.

There are two modules, which support the usage of threads in Python3-

- _thread
- threading

The thread module has been "deprecated" for quite a long time. Users are encouraged to use the threading module instead. Hence, in Python 3, the module "thread" is not available anymore. However, it has been renamed to "_thread" for backward compatibilities in Python3.

Starting a New Thread

To spawn another thread, you need to call the following method available in the *thread* module-

```
_thread.start_new_thread ( function, args[, kwargs] )
```

This method call enables a fast and efficient way to create new threads in both Linux and Windows.

The method call returns immediately and the child thread starts and calls function with the passed list of *agrs*. When the function returns, the thread terminates.

Here, *args* is a tuple of arguments; use an empty tuple to call function without passing any arguments. *kwargs* is an optional dictionary of keyword arguments.

Example

```
#!/usr/bin/python3

import _thread
import time

# Define a function for the thread
def print_time( threadName, delay):
   count = 0
   while count < 5:
      time.sleep(delay)
      count += 1
      print ("%s: %s" % ( threadName, time.ctime(time.time()) ))

# Create two threads as follows
try:
   _thread.start_new_thread( print_time, ("Thread-1", 2, ) )
   _thread.start_new_thread( print_time, ("Thread-2", 4, ) )
except:
   print ("Error: unable to start thread")

while 1:
   pass
```

When the above code is executed, it produces the following result-

```
Thread-1: Fri Feb 19 09:41:39 2016
Thread-2: Fri Feb 19 09:41:41 2016
Thread-1: Fri Feb 19 09:41:41 2016
Thread-1: Fri Feb 19 09:41:43 2016
Thread-2: Fri Feb 19 09:41:45 2016
Thread-1: Fri Feb 19 09:41:45 2016
Thread-1: Fri Feb 19 09:41:47 2016
Thread-2: Fri Feb 19 09:41:49 2016
Thread-2: Fri Feb 19 09:41:53 2016
```

Program goes in an infinite loop. You will have to press ctrl-c to stop.

Although it is very effective for low-level threading, the *thread* module is very limited compared to the newer threading module.

The Threading Module

The newer threading module included with Python 2.4 provides much more powerful, high-level support for threads than the thread module discussed in the previous section.

The *threading* module exposes all the methods of the *thread* module and provides some additional methods:

- **threading.activeCount():** Returns the number of thread objects that are active.
- **threading.currentThread():** Returns the number of thread objects in the caller's thread control.
- **threading.enumerate():** Returns a list of all the thread objects that are currently active.

In addition to the methods, the threading module has the *Thread* class that implements threading. The methods provided by the *Thread* class are as follows:

- **run():** The run() method is the entry point for a thread.
- **start():** The start() method starts a thread by calling the run method.
- **join([time]):** The join() waits for threads to terminate.
- **isAlive():** The isAlive() method checks whether a thread is still executing.
- **getName():** The getName() method returns the name of a thread.
- **setName():** The setName() method sets the name of a thread.

Creating Thread Using Threading Module

To implement a new thread using the threading module, you have to do the following –

- Define a new subclass of the *Thread* class.
- Override the *__init__(self [,args])* method to add additional arguments.
- Then, override the run(self [,args]) method to implement what the thread should do when started.

Once you have created the new *Thread* subclass, you can create an instance of it and then start a new thread by invoking the *start()*, which in turn calls the *run()*method.

Example

```
#!/usr/bin/python3
```

```
import threading
import time
exitFlag = 0
class myThread (threading.Thread):
    def __init__(self, threadID, name, counter):
        threading.Thread.__init__(self)
        self.threadID = threadID
        self.name = name
        self.counter = counter
    def run(self):
        print ("Starting " + self.name)
        print_time(self.name, self.counter, 5)
        print ("Exiting " + self.name)

def print_time(threadName, delay, counter):
    while counter:
        if exitFlag:
            threadName.exit()
        time.sleep(delay)
        print ("%s: %s" % (threadName, time.ctime(time.time())))
        counter -= 1

# Create new threads
thread1 = myThread(1, "Thread-1", 1)
thread2 = myThread(2, "Thread-2", 2)

# Start new Threads
thread1.start()
thread2.start()
thread1.join()
thread2.join()
print ("Exiting Main Thread")
```

When we run the above program, it produces the following result-

```
Starting Thread-1
Starting Thread-2
Thread-1: Fri Feb 19 10:00:21 2016
Thread-2: Fri Feb 19 10:00:22 2016
Thread-1: Fri Feb 19 10:00:22 2016
```

```
Thread-1: Fri Feb 19 10:00:23 2016
Thread-2: Fri Feb 19 10:00:24 2016
Thread-1: Fri Feb 19 10:00:24 2016
Thread-1: Fri Feb 19 10:00:25 2016
Exiting Thread-1
Thread-2: Fri Feb 19 10:00:26 2016
Thread-2: Fri Feb 19 10:00:28 2016
Thread-2: Fri Feb 19 10:00:30 2016
Exiting Thread-2
Exiting Main Thread
```

Synchronizing Threads

The threading module provided with Python includes a simple-to-implement locking mechanism that allows you to synchronize threads. A new lock is created by calling the *Lock()* method, which returns the new lock.

The *acquire(blocking)* method of the new lock object is used to force the threads to run synchronously. The optional *blocking* parameter enables you to control whether the thread waits to acquire the lock.

If *blocking* is set to 0, the thread returns immediately with a 0 value if the lock cannot be acquired and with a 1 if the lock was acquired. If blocking is set to 1, the thread blocks and wait for the lock to be released.

The *release()* method of the new lock object is used to release the lock when it is no longer required.

Example

```
#!/usr/bin/python3
import threading
import time
class myThread (threading.Thread):
    def __init__(self, threadID, name, counter):
        threading.Thread.__init__(self)
        self.threadID = threadID
        self.name = name
        self.counter = counter
    def run(self):
        print ("Starting " + self.name)
        # Get lock to synchronize threads
        threadLock.acquire()
        print_time(self.name, self.counter, 3)
```

```
        # Free lock to release next thread
        threadLock.release()
def print_time(threadName, delay, counter):
    while counter:
        time.sleep(delay)
        print ("%s: %s" % (threadName, time.ctime(time.time())))
        counter -= 1

threadLock = threading.Lock()
threads = []

# Create new threads
thread1 = myThread(1, "Thread-1", 1)
thread2 = myThread(2, "Thread-2", 2)

# Start new Threads
thread1.start()
thread2.start()

# Add threads to thread list
threads.append(thread1)
threads.append(thread2)

# Wait for all threads to complete
for t in threads:
    t.join()
print ("Exiting Main Thread")
```

When the above code is executed, it produces the following result-

```
Starting Thread-1
Starting Thread-2
Thread-1: Fri Feb 19 10:04:14 2016
Thread-1: Fri Feb 19 10:04:15 2016
Thread-1: Fri Feb 19 10:04:16 2016
Thread-2: Fri Feb 19 10:04:18 2016
Thread-2: Fri Feb 19 10:04:20 2016
Thread-2: Fri Feb 19 10:04:22 2016
Exiting Main Thread
```

Multithreaded Priority Queue

The *Queue* module allows you to create a new queue object that can hold a specific number of items. There are following methods to control the Queue –

- **get():** The get() removes and returns an item from the queue.
- **put():** The put adds item to a queue.
- **qsize() :** The qsize() returns the number of items that are currently in the queue.
- **empty():** The empty( ) returns True if queue is empty; otherwise, False.
- **full():** the full() returns True if queue is full; otherwise, False.

Example

```
#!/usr/bin/python3

import queue
import threading
import time

exitFlag = 0

class myThread (threading.Thread):
    def __init__(self, threadID, name, q):
        threading.Thread.__init__(self)
        self.threadID = threadID
        self.name = name
        self.q = q
    def run(self):
        print ("Starting " + self.name)
        process_data(self.name, self.q)
        print ("Exiting " + self.name)

def process_data(threadName, q):
    while not exitFlag:
        queueLock.acquire()
        if not workQueue.empty():
            data = q.get()
            queueLock.release()
            print ("%s processing %s" % (threadName, data))
        else:
            queueLock.release()
```

```
        time.sleep(1)

threadList = ["Thread-1", "Thread-2", "Thread-3"]
nameList = ["One", "Two", "Three", "Four", "Five"]
queueLock = threading.Lock()
workQueue = queue.Queue(10)
threads = []
threadID = 1

# Create new threads
for tName in threadList:
    thread = myThread(threadID, tName, workQueue)
    thread.start()
    threads.append(thread)
    threadID += 1

# Fill the queue
queueLock.acquire()
for word in nameList:
    workQueue.put(word)
queueLock.release()

# Wait for queue to empty
while not workQueue.empty():
    pass

# Notify threads it's time to exit
exitFlag = 1

# Wait for all threads to complete
for t in threads:
    t.join()
print ("Exiting Main Thread")
```

When the above code is executed, it produces the following result-

```
Starting Thread-1
Starting Thread-2
Starting Thread-3
```

```
Thread-1 processing One
Thread-2 processing Two
Thread-3 processing Three
Thread-1 processing Four
Thread-2 processing Five
Exiting Thread-3
Exiting Thread-1
Exiting Thread-2
Exiting Main Thread
```