Experiment No. 7

Title: Program on Multithreading using Python

Batch:A3 **Roll No: 16010423099** **Experiment No.:7**

Aim: Program on implementation of multithreading in Python

Resources needed: Python IDE

Theory:

What is thread?

In computing, a process is an instance of a computer program that is being executed. Any process has 3 basic components:

- An executable program.
- The associated data needed by the program (variables, work space, buffers, etc.)
- The execution context of the program (State of process)

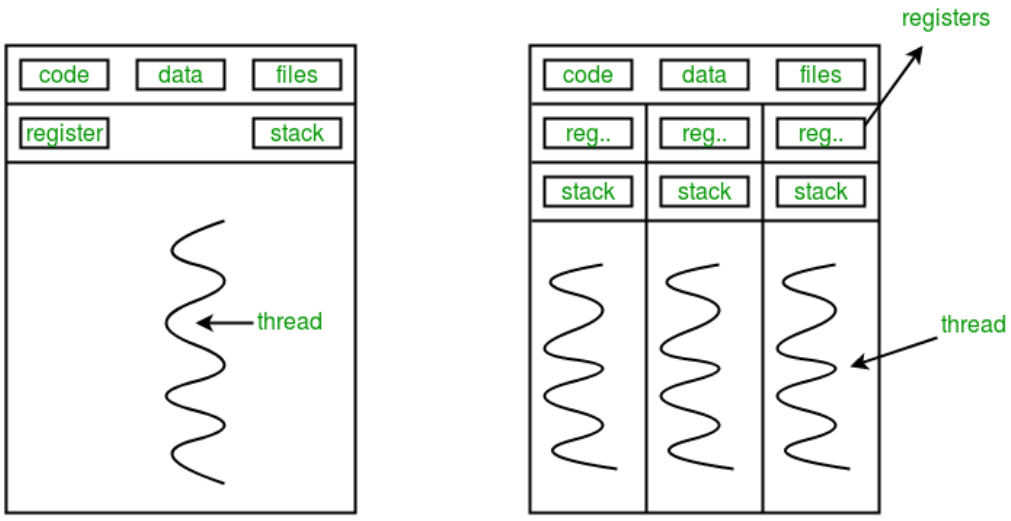
A thread is an entity within a process that can be scheduled for execution independently. Also, it is the smallest unit of processing that can be performed in an OS (Operating System).

What is Multithreading?

Multiple threads can exist within one process where:

- Each thread contains its own **register set** and **local variables (stored in stack)**.
- All thread of a process share **global variables (stored in heap)** and the **program code**.

Consider the diagram below to understand how multiple threads exist in memory:



single-threaded process multithreaded process

Multithreading is defined as the ability of a processor to execute multiple threads concurrently.
Multithreading in Python
In Python, the **threading** module provides a very simple and intuitive API for spawning multiple threads in a program.

```
# Python program to illustrate the concept of threading
# importing the threading module

import threading

def print_cube(num):
        """
        function to print cube of given num
        """

if __name__ == "__main__":
        # creating thread
        t1 = threading.Thread(target=print_square, args=(10,))
                # starting thread 1
        t1.start()

        # wait until thread 1 is completely executed
        t1.join()

        # both threads completely executed
        print("Done!")
```

Creating a new thread and related methods: Using object of Thread class from threading module.

To create a new thread, we create an object of Thread class. It takes following arguments:

target: the function to be executed by thread

args: the arguments to be passed to the target function

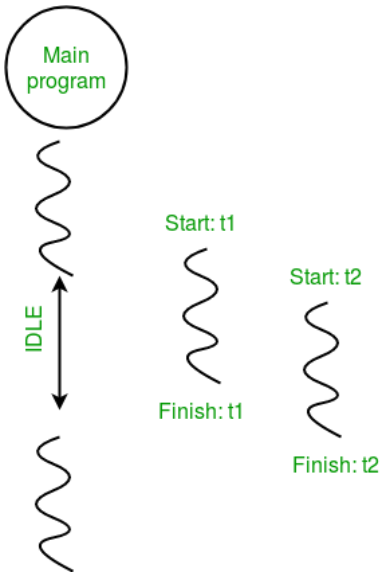
Once the threads start, the current program (you can think of it like a main thread) also keeps on executing. In order to stop execution of current program until a thread is complete, we use join method.

t1.join()

t2.join()

As a result, the current program will first wait for the completion of t1 and then t2. Once, they are finished, the remaining statements of current program are executed..

Diagram below depicts actual process of execution.



Threading.current_thread().name this will print current thread's name and threading.main_thread().name will print main thread's name. **os.getpid()** function to get ID of current process.

Thread synchronization is defined as a mechanism which ensures that two or more concurrent threads do not simultaneously execute some particular program segment. Concurrent accesses to shared resource can lead to race condition.

A race condition occurs when two or more threads can access shared data and they try to change it at the same time. As a result, the values of variables may be unpredictable and vary depending on the timings of context switches of the processes.

For example two threads trying to increment shared variable value may read same initial values and produce wrong result.

Hence there is requirement of acquiring lock on shared resource before use. **threading** module provides a **Lock** class to deal with the race conditions.

Lock class provides following methods:

acquire([blocking]) : To acquire a lock. A lock can be blocking or non-blocking.

When invoked with the blocking argument set to True (the default), thread execution is blocked until the lock is unlocked, then lock is set to locked and return True.

When invoked with the blocking argument set to False, thread execution is not blocked. If lock is unlocked, then set it to locked and return True else return False immediately.

release() : To release a lock.

When the lock is locked, reset it to unlocked, and return. If any other threads are blocked waiting for the lock to become unlocked, allow exactly one of them to proceed.

If lock is already unlocked, a ThreadError is raised.

Firstly, a Lock object is created using:

```
lock = threading.Lock()
```

Then, lock is passed as target function argument:

```
t1 = threading.Thread(target=thread_task, args=(lock,))
t2 = threading.Thread(target=thread_task, args=(lock,))
```

In the critical section of target function, we apply lock using lock.acquire() method. As soon as a lock is acquired, no other thread can access the critical section (here, increment function) until the lock is released using lock.release() method.

Activities:

a) Write a program to create three threads. Thread 1 will generate random number. Thread two will compute square of this number and thread 3 will compute cube of this number

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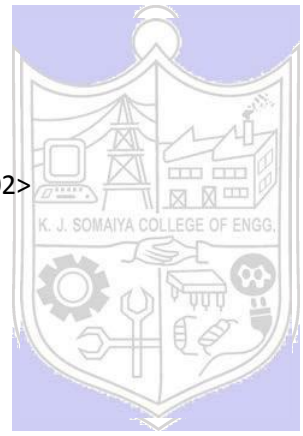
Result: (script and output)

```
import threading
import random



number = None



def generate_random_number():
    global number
    number = random.randint(1, 100)
    print(f"Generated random number: {number}")



def compute_square():
    global number
    if number is not None:
        square = number ** 2
        print(f"Square of {number}: {square}")
    else:
        print("Number not generated yet.")



def compute_cube():
    global number
    if number is not None:
        cube = number ** 3
        print(f"Cube of {number}: {cube}")
    else:
        print("Number not generated yet.")



thread1 = threading.Thread(target=generate_random_number)
```

```
thread2 = threading.Thread(target=compute_square)
thread3 = threading.Thread(target=compute_cube)



thread1.start()
thread1.join()
thread2.start()
thread2.join()

thread3.start()
thread3.join()
```

output:

```
Generated random number: 48
Square of 48: 2304
Cube of 48: 110592
PS C:\Users\Student\Desktop\aashna-02>
```



Outcomes:

Design python applications using GUI design, database connectivity and multithreading

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Questions:

a) What are other ways to create threads in python? Give examples.

`threading.Thread`: Create a thread by specifying a target function when instantiating the `Thread` class.

Subclassing `threading.Thread`: Subclass `Thread` and override the `run` method to define thread behavior.

`concurrent.futures.ThreadPoolExecutor`: Use this higher-level interface to manage a pool

of threads for executing tasks concurrently.
Using `queue.Queue`: Implement a worker pattern where threads communicate through a queue for thread-safe processing.
`multiprocessing` Module: While primarily for processes, this can achieve similar parallel execution to threads but with separate memory spaces.

b) How wait() and notify() methods can be used with lock in thread?

`wait()`:

- A thread calls `wait()` on a condition variable when it needs to pause execution until another thread signals that it can continue.
- This method automatically releases the associated lock, allowing other threads to acquire it while the current thread is waiting.

`notify()`:

- A thread can call `notify()` on a condition variable to wake up one or more threads that are waiting for the condition.
- This should be done while holding the associated lock to ensure that the waiting threads can check the condition safely.

Conclusion:
Successfully run a Program on implementation of multithreading in Python.

References:

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