Threading in Python

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Hello

Hello (1)

Learning Outcomes

1. Understand the concept of threading in Python
2. Demonstrate their knowledge on the use of threading in Python

Threading

Threading (1)

- A *thread* refers to a basic unit of CPU utilisation
  - a separate process that has its own instructions and data
  - it may also represent a process that is part of a parallel program
    - although it may also represent an independent program
- They share their code, data and other operating system resources with other threads belonging to the same process
- A traditional process will have a single thread of control
  - if a process has multiple threads of control, then it has the ability to perform more than one task at a time

Threading (2)

Benefits of Multithreading

1. **Responsiveness**
   - Interactive applications can continue to run, even if part of its blocked; increasing the responsiveness to the user
   - Multithreaded web browsers enable you to continue browsing the internet on one tab, whilst another tab has become unresponsive
2. **Resource Sharing**
   - Threads share memory and resources of the process they belong to
   - Benefits of sharing code and data
   - allows an application to have several threads of activity in the same address space
3. **Economy**
   - Allocation of memory and other resources for process creation is costly
   - Threads share resources of a process they belong to
     - therefore, providing a cost-effective resource
4. **Multiprocessor Architecture**
   - Threads may run in parallel on different processors, dependent upon the multiprocessor architecture
   - Single threaded processes may only run on one CPU, no matter how many CPUs may be available
   - Multithreaded processes on a multi-CPU machine can increase concurrency

Threading (3)

Difference Between Process and Thread i

- In multithreading, a process and thread are two closely related terms
  - they have the same goal to make a computer run tasks simultaneously
- A *process* can contain one or more threads, whilst a *thread* cannot contain a process

Threading (4)

Difference Between Process and Thread ii

Process

- An execution of a script/program to perform a task
- The operating system will assist in the creation, scheduling and termination of the processes
- Spawned processes from the main process are known as **child** processes
- The properties of a process are:
  - creating each process requires separate system calls for each process
  - an isolated execution entity and does not share data or information
  - requires more system calls to manage

Threading (5)

Difference Between Process and Thread iii

Thread

- An execution of a segment that is part of the process
  - a process can consist of **multiple** threads
  - all threads will be executed at the same time
- Considered to be lightweight and managed by a scheduler
- The properties of a thread are:
  - a single system call can create multiple threads
  - threads can share data and information between themselves
  - management of threads consumes fewer (or none) system calls

Threading (6)

Advantages and Disadvantages of Threading i

Advantages

- **Speed**
  - Multithreading can improve the speed of computation
  - Each core (or processor) can handle separate threads concurrently.
- **Responsiveness**
  - Applications can remain responsive as one thread waits for the input
  - Another thread can run the GUI at the same time
- **Variable Accessibility**
  - All threads of a particular process can access global variables
  - If a change is made to a global variable, then it is visible in the other threads too
- **Resource Utilisation**
  - Running several threads in each application utilises the resources of a CPU better
  - Idle time of a CPU decreases
- **Data Sharing**
  - No requirement for extra space to be created for each thread
  - Threads within an application can share the same data

Threading (7)

Advantages and Disadvantages of Threading ii

Disadvantages

- **Suitability**
  - Multithreading is not suitable for single processor systems
  - Difficult to achieve performance gains compared to a multiprocessor system
- **Security**
  - As threads can share the same data, there is an issue with security
  - Any unknown thread may make changes to the data
- **Complex**
  - Multithreading can increase the complexity of the application and debugging
- **Possible Deadlock**
  - There is a possibility of leading to a deadlock state
  - *Deadlock* is a situation where a set of processes are blocked
    - this is due to each process is holding a resource and is awaiting another acquired by a different process
- **Synchronisation**
  - Avoiding mutual exclusion is achieved by synchronisation
  - Leads to more memory and CPU utilisation

Multithreading Models

Multithreading Models (1)

- There are two types of threads:
  1. User Level
  2. Kernel Level

Multithreading Models (2)

User Level Threads

- These are threads managed by the **user**
- The thread management kernel is not aware of the existence of these threads
- The library used for managing threads can be used to:
  - create and delete threads
  - pass messages and data between threads
  - schedule thread execution
  - save and restore thread contexts
- **Advantages**:
  - Switching threads does not require kernel mode privileges
  - User level threads can run on any operating system
  - These types of threads are fast to create and manage
- **Disadvantages**:
  - For a typical operating system, most system calls are blocked
  - A multithreaded application cannot take advantage of multiprocessing

Multithreading Models (3)

Kernel Level Threads

- These are threads managed by the operating system
  - there is no thread management code in the application
- Any application can be programmed to be multithreaded
- All the threads in the application are supported within a single process
- The kernel maintains context information for the process as a whole
  - along with the individual threads within the process
- Scheduling by the kernel is done on a thread basis
  - performs the thread creation, scheduling and management in the kernel space
- **Advantages**:
  - Simultaneous scheduling of multiple threads from the same process on multiple processes
  - If a single thread is blocked, the kernel is able to schedule another thread for the same process
- **Disadvantages**:
  - Generally slower to create and manage compared to user-level threads
  - Transfer of control from one thread to another within the same process requires a mode switch

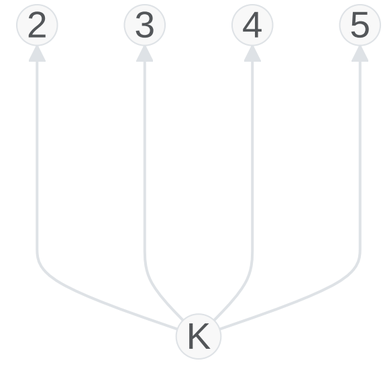
Multithreading Models (4)

- There are three methods of modeling a multithreaded application:
  1. Many-to-One
  2. Many-to-Many
  3. One-to-One

Multithreading Models (5)

Many-to-One

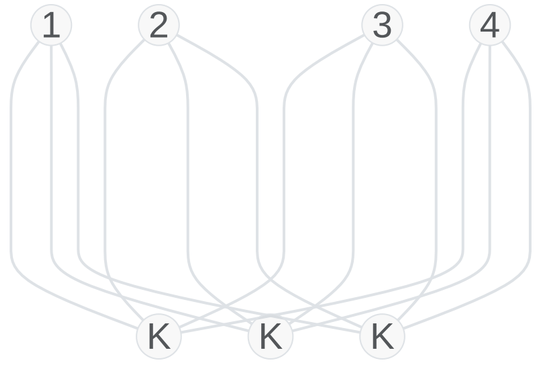
- Maps many user-level threads to one kernel thread
- Management of the thread is done by the thread library in the user-space
- Only a single thread can access the kernel at a time
  - therefore, multiple threads are unable to run in parallel on multiprocessors



Multithreading Models (6)

Many-to-Many

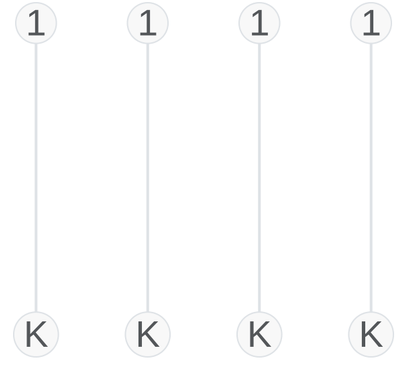
- Joins many user-level threads to a smaller or equal number of kernel threads
- The number of kernel threads may be specific to a particular application or machine
- Developers are able to create as many user threads as necessary
  - the corresponding kernel threads can run in parallel on multiprocessor machines



Multithreading Models (7)

One-to-One

- Maps each user-level thread to a kernel thread
- Provides more concurrency than the many-to-one model
  - allows multiple threads to run in parallel on multiprocessors
- Creating a user thread requires creating the corresponding kernel thread
- The overhead required for creating a kernel thread can be a burden on the performance of the application



Multithreading in Python

Multithreading in Python (1)

- Python has two libraries available for multithreading applications:
  1. `_thread`: each thread is a function
  2. `threading`: each thread is an object
- For the purpose of this module, we shall be focusing upon the `threading` module
  - `_thread` is considered to be deprecated

Multithreading in Python (2)

Creating a Threaded Application

- Implement threads in an object-oriented methodology, as such providing high-level support
- To implement a thread, the `Thread` class is used
  - e.g. `from theading import Thread`
- We can then create an instance of the `Thread` class
- Specify the function to run in the `target` argument
- Execute the thread using the `start` function

```
from threading import Thread
def hello():
    print("Hello 5062CEM!")
threadExample1 = Thread(target=hello)
```

```
threadExample1.start() -> Hello 5062CEM!
```

Multithreading in Python (3)

Running a Function with an Argument

- Create an instance of the `Thread` class
- Specify the function to run in the `target` argument
- Specify the arguments to pass th`rough in theargs` argument
  - provide the arguments as **list**
- Execute the thread using the `start` function

```
from threading import Thread
def hello(name):
    print(f"Hello {name}, and welcome to 5062CEM!")
threadExample1  = Thread(target=hello, args=(['Ian Cornelius']))
```

```
threadExample1.start() -> Hello Ian Cornelius, and welcome to 5062CEM!
```

Multithreading in Python (4)

Running a Function with Multiple Arguments

- Create an instance of the `Thread` class
- Specify the function to run in the `target` argument
- Specify the arguments to pass through in the `args` argument
  - provide the arguments as **list**
- Execute the thread using the `start` function

```
from threading import Thread
def hello(name, module):
    print(f"Hello {name}, and welcome to {module}!")
threadExample1 = Thread(target=hello, args=['Ian Cornelius', '5062CEM'])
```

```
threadExample1.start() -> Hello Ian Cornelius, and welcome to 5062CEM!
```

Multithreading in Python (5)

Creating a Custom Thread Class

- Extend an instance of the `Thread` class
- Override the `run` function
- Provide variable names with the `self` keyword
- Return the string to the `self.data` variable

```
from threading import Thread
class MyThread(Thread):
    def __init__(self, name, module):
        Thread.__init__(self)
        self.name = name
        self.module = module
        self.data = None
    def run(self):
        self.data = f"Hello {self.name}, and welcome to {self.modu
customThreadExample1 = MyThread("Ian Cornelius ", "5062CEM")
customThreadExample2 = MyThread("Terry Richards", "5069CEM")
```

```
customThreadExample1.data -> Hello Ian Cornelius , and welcome to 5062CEM!
customThreadExample2.data -> Hello Terry Richards, and welcome to 5069CEM!
```

Multithreading in Python (6)

Extending the Custom Thread Class

- Extend an instance of the `Thread` class
- Override the `run` function
- Provide variable names with the `self` keyword
  - add a new variable called `sleep`
- Return the string to the `self.data` variable

```
from threading import Thread
class MyThread(Thread):
    def __init__(self, name, module, sleep):
        Thread.__init__(self)
        self.name = name
        self.module = module
        self.sleep = sleep
        self.data = None
    def run(self):
        from time import sleep
        sleep(self.sleep)
        self.data = f"Hello {self.name}, and welcome to {self.modu
customThreadExample1 = MyThread("Ian Cornelius ", "5062CEM", 10)
```

```
customThreadExample1.data -> Hello Ian Cornelius , and welcome to 5062CEM!
customThreadExample2.data -> Hello Terry Richards, and welcome to 5069CEM!
```

Goodbye

Goodbye (1)

Questions and Support

- Questions? Post them on the **Community Page** on Aula
- Additional Support? Visit the Module Support Page
- Contact Details:
  - Dr Ian Cornelius, ab6459@coventry.ac.uk