

Outline

MCS 260 L-39

28 November 2007

Concurrent Processes

- processes and threads
- life cycle of a thread

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- life cycle of a thread

Multithreading in Python

- the thread module
- the Thread class

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- the Thread class

Producer/Consumer Relation

Producer/Consumer Relation

MCS 260 Lecture 39
Introduction to Computer Science
Jan Verschelde, 28 November 2007

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Parallel Processing

processes and threads

At any given time, many processes are running simultaneously on a computer.

The operating system employs *time sharing* to allocate a percentage of the CPU time to each process.

Consider for example the downloading of an audio file. Instead of having to wait till the download is complete, we would like to listen sooner.

Processes have their own memory space, whereas threads share memory and other data. Threads are often called lightweight processes.

A thread is short for *a thread of execution*, it typically consists of one function.

A program with more than one thread is *multithreaded*.

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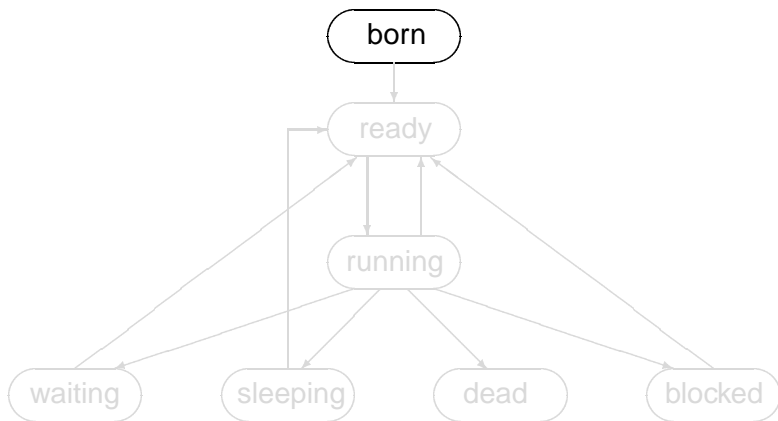
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Producer/Consumer Relation

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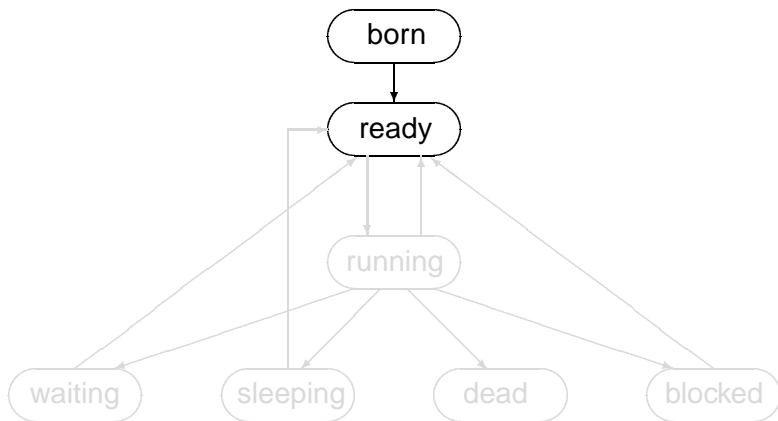
the Life Cycle of a Thread

a state diagram



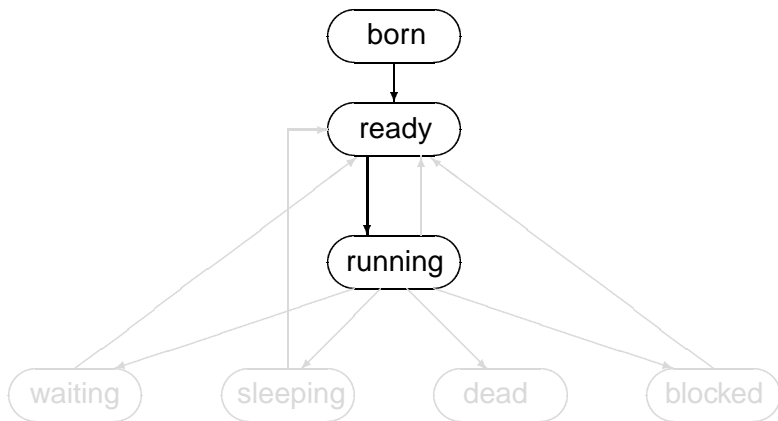
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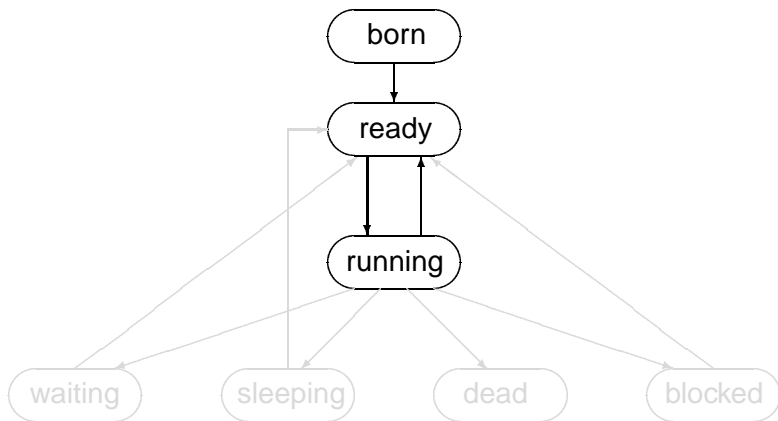
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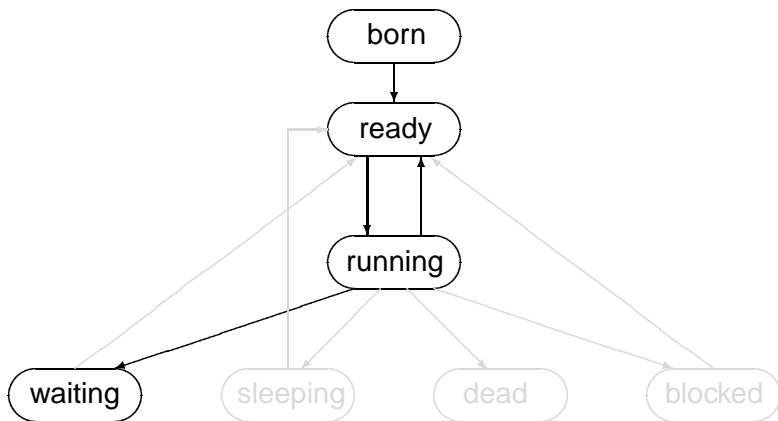
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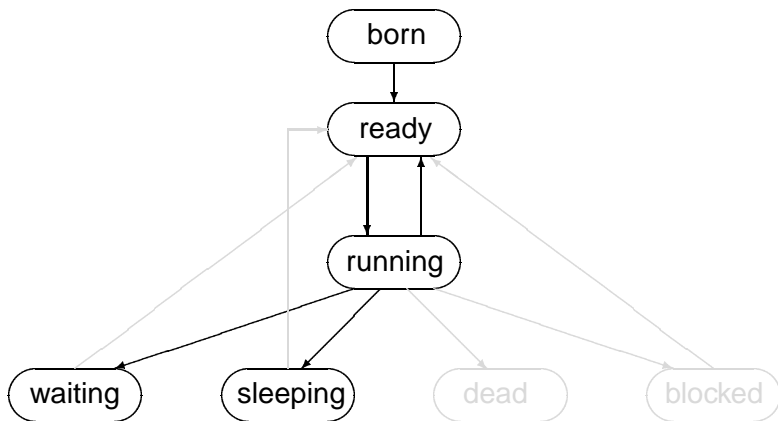
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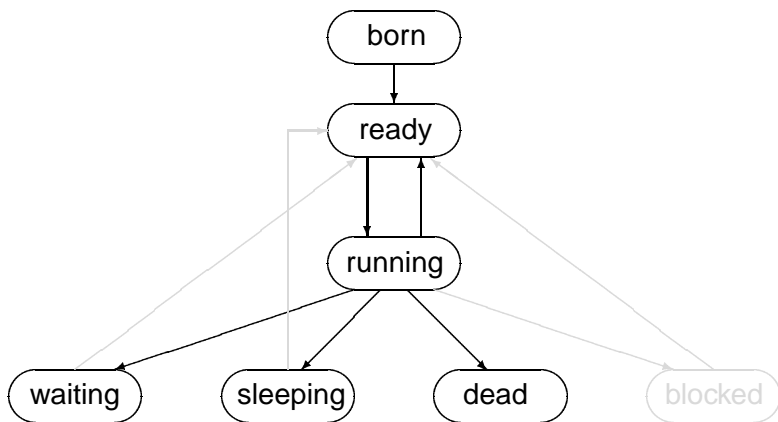
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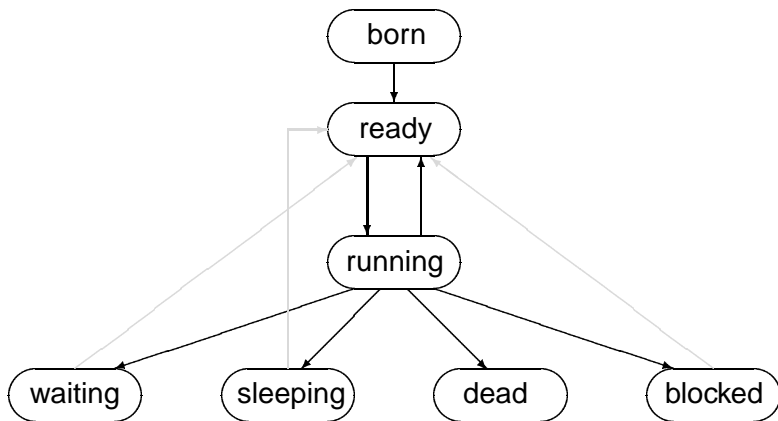
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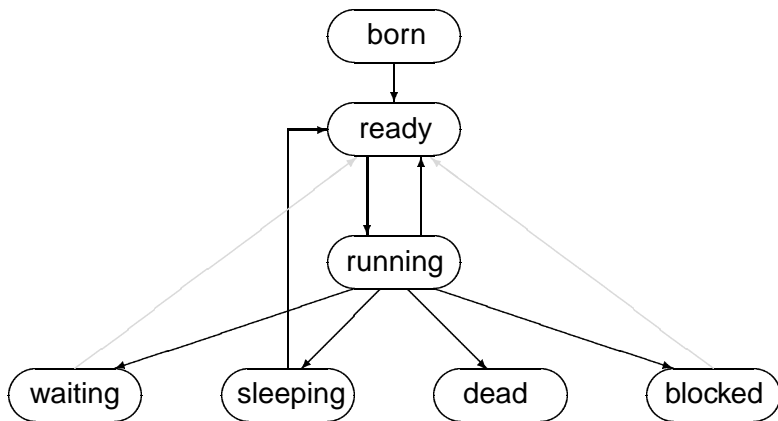
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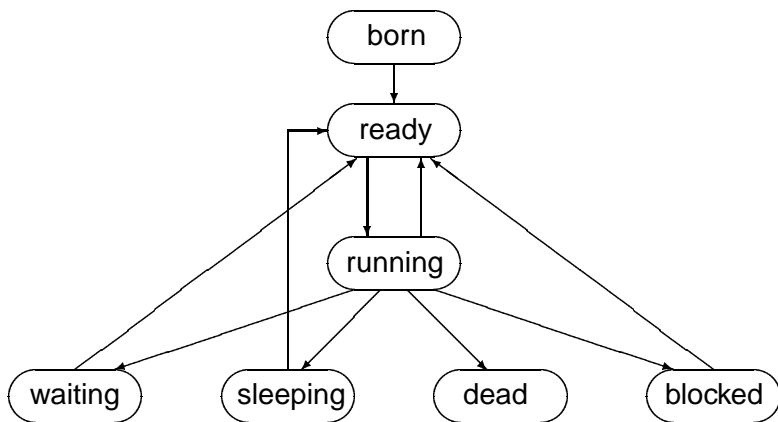
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have threads say hello

with the thread module

Our first multithreading Python code will

1. import the thread module
2. start three threads using `thread.start_new_thread`
3. each thread will say hello and sleep for `n` seconds
4. after starting the threads we must wait long enough for all threads to finish

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the program `hello_threads.py`

using the thread module

```
import thread
import time

def say_hello(name,n):
    "says hello and sleeps n seconds"
    print "hello from " + name
    time.sleep(n)
    print name + " slept %d seconds" % n

print "starting three threads"
thread.start_new_thread(say_hello,("first thread",3))
thread.start_new_thread(say_hello,("second thread",2))
thread.start_new_thread(say_hello,("third thread",1))
time.sleep(4) # we must wait for all to finish!
print "done running the threads"
```

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running hello_threads

a screen shot

At the command prompt \$:

```
$ python hello_threads.py
starting three threads
hello from first thread
hello from second thread
hello from third thread
third thread slept 1 seconds
second thread slept 2 seconds
first thread slept 3 seconds
done running the threads
$
```

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The threading module exports the Thread class.

We create new threads by inheriting from `threading.Thread`, overriding the `__init__` and `run`.

After creating a thread object, a new thread is born.

With `run`, we start the thread.

Main difference with the `thread` module is the explicit difference between the born and running state.

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running hello_threading

At the command prompt \$:

```
$ python hello_threading.py
first thread is born
second thread is born
third thread is born
starting threads
hello from first thread
hello from second thread
hello from third thread
threads started
third thread slept 1 seconds
second thread slept 4 seconds
first thread slept 5 seconds
$
```

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the Class HelloThread

its structure

```
import threading
import time
import random

class HelloThread(threading.Thread):
    """
    hello world with threads
    """
    def __init__(self,t):
        "initializes thread with name t"

    def run(self):
        "says hello and sleeps awhile"

def main():
    "starts three threads"

if __name__ == "__main__": main()
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the Methods of HelloThread

constructor and run

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```
def __init__(self,t):
    "initializes thread with name t"
    threading.Thread.__init__(self,name=t)
    print t + " is born "

def run(self):
    "says hello and sleeps awhile"
    t = self.getName()
    print "hello from " + t
    r = random.randint(1,6)
    time.sleep(r)
    print t + " slept %d seconds" % r
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the main function

using HelloThread

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    t2 = HelloThread("second thread")
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    print "starting threads"
    t1.start()
    t2.start()
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Producer/Consumer Relation

with threads

A very common relation between two threads is that of producer and consumer. For example, the downloading of an audio file is production, while listening is consumption.

Our producer/consumer relation with threads uses

- ▶ an object of the class `Producer` is a thread that will append to a queue consecutive integers in a given range and at a given pace;
- ▶ an object of the class `Consumer` is a thread that will pop integers from the queue and print them, at a given pace.

If the pace of the produces is slower than the pace of the consumer, then the consumer will wait.

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If the pace of the produces is slower than the pace of the consumer, then the consumer will wait.

running the code

```
$ python prodcons.py
producer starts...
producer sleeps 1 seconds
consumption starts...
consumer sleeps 1 seconds
appending 1 to queue
producer sleeps 4 seconds
popped 1 from queue
consumer sleeps 1 seconds
wait a second...
wait a second...
wait a second...
appending 2 to queue
producer sleeps 2 seconds
popped 2 from queue
consumer sleeps 1 seconds
wait a second...
appending 3 to queue
production terminated
popped 3 from queue
consumption terminated
```

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wait a second...
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popped 2 from queue
consumer sleeps 1 seconds
wait a second...
appending 3 to queue
production terminated
popped 3 from queue
consumption terminated
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wait a second...
wait a second...
appending 2 to queue
producer sleeps 2 seconds
popped 2 from queue
consumer sleeps 1 seconds
wait a second...
appending 3 to queue
production terminated
popped 3 from queue
consumption terminated
```

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producer starts...
producer sleeps 1 seconds
consumption starts...
consumer sleeps 1 seconds
appending 1 to queue
producer sleeps 4 seconds
popped 1 from queue
consumer sleeps 1 seconds
wait a second...
wait a second...
wait a second...
appending 2 to queue
producer sleeps 2 seconds
popped 2 from queue
consumer sleeps 1 seconds
wait a second...
appending 3 to queue
production terminated
popped 3 from queue
consumption terminated
```

running the code

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$ python prodcons.py
producer starts...
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consumption starts...
consumer sleeps 1 seconds
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wait a second...
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```

Concurrent Processes

processes and threads
life cycle of a thread

Multithreading in Python

the thread module
the Thread class

Producer/Consumer Relation

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consumer sleeps 1 seconds
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production terminated
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consumption terminated
```

Structure of Producer Class

parameters and methods

```
import threading
import random
import time

class Producer(threading.Thread):
    """
    Appends integers to a queue.
    """
    def __init__(self, t, q, a, b, p):
        "thread t to add integers in [a,b] to q"
    def run(self):
        "produces integers at some pace"
```

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Methods of Producer Class

constructor

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```
def __init__(self,t,q,a,b,p):
    """
    Thread t to add integers in [a,b] to q
    sleeping between 1 and p seconds.
    """
    threading.Thread.__init__(self,name=t)
    self.queue = q
    self.begin = a
    self.end = b
    self.pace = p
```

Methods of Producer Class

constructor

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The Production Method

of class Producer

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```
def run(self):
    "produces integers at some pace"
    print self.getName() + " starts..."
    for i in range(self.begin, self.end+1):
        r = random.randint(1, self.pace)
        print self.getName() + \
            " sleeps %d seconds" % r
        time.sleep(r)
        print "appending %d to queue" % i
        self.queue.append(i)
    print "production terminated"
```

The Production Method

of class Producer

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    print "production terminated"
```

Structure of Consumer Class

constructor and run

```
import threading
import random
import time

class Consumer(threading.Thread):
    """
    Pops integers from a queue.
    """
    def __init__(self, t, q, n, p):
        "thread t to pop n integers from q"

    def run(self):
        "pops integers at some pace"
```

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Structure of Consumer Class

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Constructor of Consumer Class

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```
def __init__(self,t,q,n,p):  
    "thread t to pop n integers from q"  
    threading.Thread.__init__(self,name=t)  
    self.queue = q  
    self.amount = n  
    self.pace = p
```

Constructor of Consumer Class

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```

Consuming Elements

the method run

```
def run(self):
    "pops integers at some pace"
    print "consumption starts..."
    for i in range(0,self.amount):
        r = random.randint(1,self.pace)
        print self.getName() + \
            " sleeps %d seconds" % r
        time.sleep(r)
    while True:
        try:
            i = self.queue.pop(0)
            print "popped %d from queue" % i
            break
        except IndexError:
            print "wait a second..."
            time.sleep(1)
    print "consumption terminated"
```

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def run(self):
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the main program

prodcons.py

Code for the class `Producer` and `Consumer` in modules `classproducer` and `classconsumer` respectively.

```
from classproducer import *
from classconsumer import *

q = []          # queue is shared list
p = Producer("producer",q,1,3,4)
c = Consumer("consumer",q,3,1)

p.start()      # start threads
c.start()

p.join()       # wait for thread to finish
c.join()
```

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Summary + Assignments

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We started chapter 13 in *Making Use of Python*.

Assignments:

1. Modify the producer/consumer relationship into card dealing. The producer is the card dealer, the consumer stores the received cards in a hand.
2. When running a large simulation, e.g.: testing the distribution of a random number generator, it is useful to consider the evolution of the histogram. Design a multithreaded program where the producer generates random numbers that are then classified by the consumer.

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