

Concurrent Programming (Part 3)

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Objectives

- We will cover:
 - Thread conditions
 - Environment variables

Agenda

- **Thread conditions**
- Environment variables

Thread Conditions

```
$ python locking.py
```

```
1
```

```
2
```

```
3
```

```
1
```

```
-1
```

```
-3
```

```
-5
```

```
-7
```

```
-6
```

```
-5
```

```
-4
```

```
-3
```

```
-2
```

```
-1
```

```
0
```

```
Final balance: 0
```

```
$
```

Recall locking.py

Not realistic!

Thread Conditions

- **Observation** (concerning locking.py):
 - Before withdrawing, withdraw thread should **wait** for the bank account balance to be sufficiently large
 - After depositing, deposit thread should **notify** waiting threads that they can try again

Thread Conditions

- Observation (in general):
 - Sometimes a **consumer** thread must **wait** for a *condition* on a shared object to become true
 - Sometimes a **producer** thread must change the *condition*, and **notify** waiting threads that they can try again
- Implementation: ***Thread conditions***

Thread Conditions

- See **conditions.py**

```
$ python conditions.py
1
2
3
4
5
6
7
8
9
10
8
6
4
2
0
Final balance: 0
$
```

```
$ python conditions.py
1
2
3
4
5
3
1
2
3
4
5
6
4
2
0
Final balance: 0
$
```

Thread Conditions

- See **conditions.py** (cont.)
 - **`condition.notify_all()`**
 - Moves all threads waiting on this object from waiting state to runnable state
 - **`condition.wait()`**
 - Releases the lock
 - Moves current thread from runnable state to waiting state
 - Upon return, reacquires lock

Thread Conditions

- See **conditionsw.py**
 - Uses `with` statement

Thread Conditions

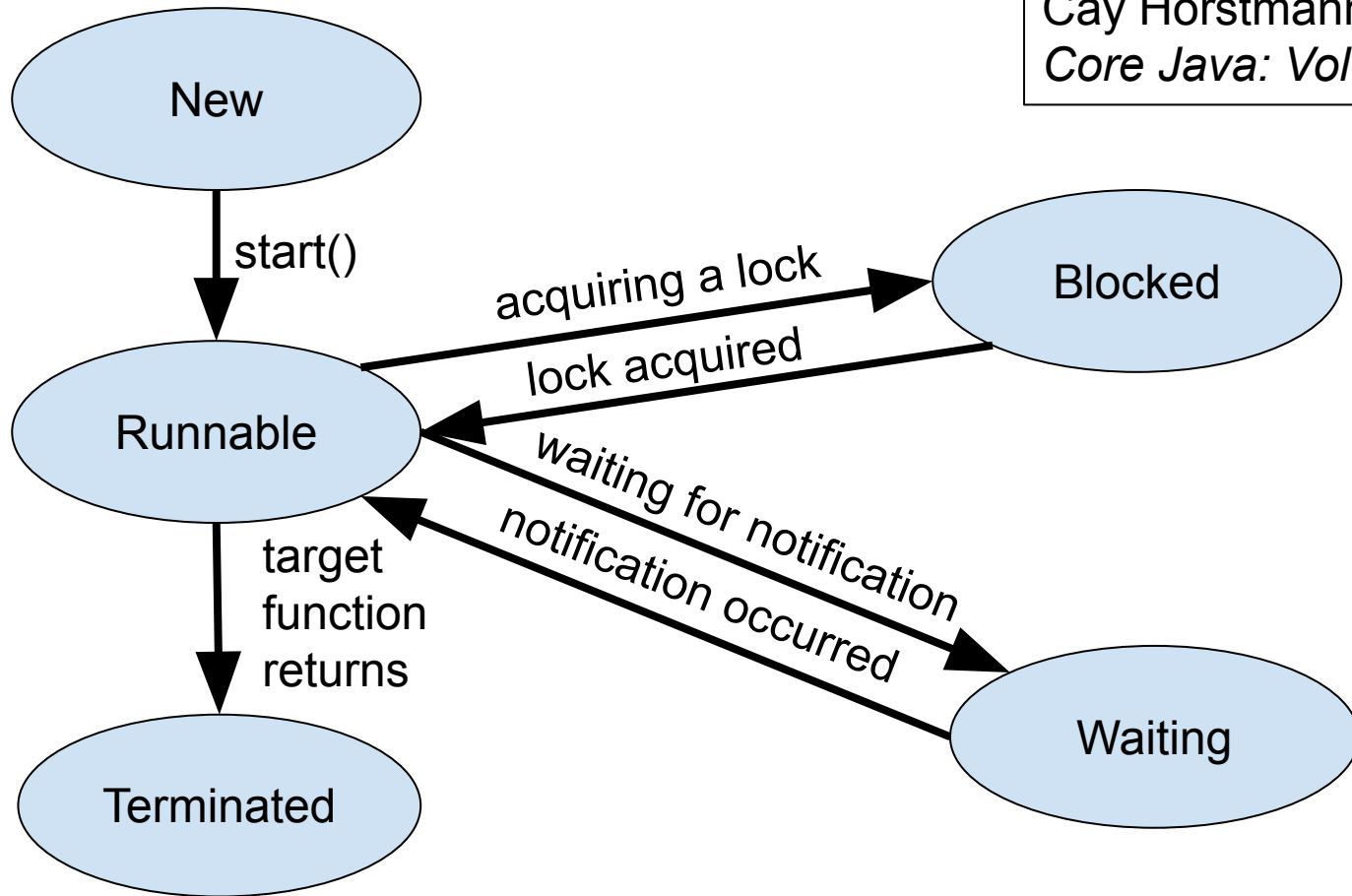
Thread conditions pattern:

```
consumer thread
    while (! objectStateOk)
        condition.wait();
    // Do what should be done when
    // objectStateOk is true.

producer thread
    // Change objectState.
    condition.notify_all();
```

Aside: Thread States

Cay Horstmann.
Core Java: Volume 1



At any time OS gives processor(s) to Runnable thread(s)

Agenda

- Thread conditions
- **Environment variables**

Environment Vars

- ***Environment variables***
 - Each process has a set of environment variables
 - `PATH=...`
 - `SHELL=...`
 - `QUERY_STRING=...`
 - ...
 - Each child process inherits the environment variables of its parent process

Environment Vars

In the Bash shell (on Linux or Mac):

```
$ export XXX=yyy
$ printenv
...
XXX=yyy
...
$ printenv XXX
YYY
$ echo $XXX
YYY
$ unset XXX
$ printenv XXX
$
```

Environment Vars

In a Command Prompt window (on MS Windows):

```
C:\>set XXX=yyy  
C:\>echo %XXX%  
yyy  
C:\>set XXX=  
C:\>echo %XXX%  
C:\>
```

Environment Vars

In Python:

```
$ python
>>> import os
>>> os.environ['XXX'] = 'yyy'
>>> os.environ['XXX']
'yyy'
>>> os.environ['ZZZ']
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "<frozen os>", line 714, in
__getitem__ KeyError: 'ZZZ'
>>> os.environ.get('XXX')
'yyy'
>>> os.environ.get('ZZZ')
>>> os.environ.get('ZZZ', 'somedefault')
'somedefault'
>>> quit()
$
```

Environment Vars

- **Question:**
 - How can a Python process accept data from its user?
- **Answers:**
 - By reading it (from stdin, a file, a socket, or a pipe)
 - Through a command-line argument
 - Through an **environment variable**

Environment Vars

- See **envvar1.py**

```
$ export GREETING=hello
$ python envvar1.py
hello
$ unset GREETING
$ python envvar1.py
hi
$
```

Environment Vars

- The Python *dotenv* module
 - Python-specific mechanism for setting/getting env vars
 - To install:

```
$ python -m pip install python-dotenv
```

Environment Vars

- The Python *dotenv* module (cont.)
 - To use in Python code (step 1)

.env file:

```
SOMEVAR=somevalue
```

```
...
```

Environment Vars

- The Python *dotenv* module (cont.)
 - To use in Python code (step 2)

.py file:

```
import dotenv
...
dotenv.load_dotenv()
SOME_VAR = os.environ.get('SOMEVAR', default)
...
```

- (1) Looks for *SOMEVAR* as env var; if not found...
- (2) Looks for *SOMEVAR* in .env file, if not found...
- (3) Uses *default*

Environment Vars

- See envvar2.py

Created first:

```
$ cat .env  
GREETING=hello  
$
```

Then:

```
$ export GREETING=bonjour  
$ python envvar2.py  
bonjour  
$ unset GREETING  
$ python envvar2.py  
hello  
$ rm .env  
$ python envvar2.py  
hi  
$
```

Lecture Summary

- In this lecture we covered:
 - Thread conditions
 - Environment variables
- See also:
 - **Appendix 1:** Inter-Process Communication
 - **Appendix 2:** Inter-Thread Communication
 - **Appendix 3:** Thread Conditions in Java

Appendix 1:

Inter-Process Communication

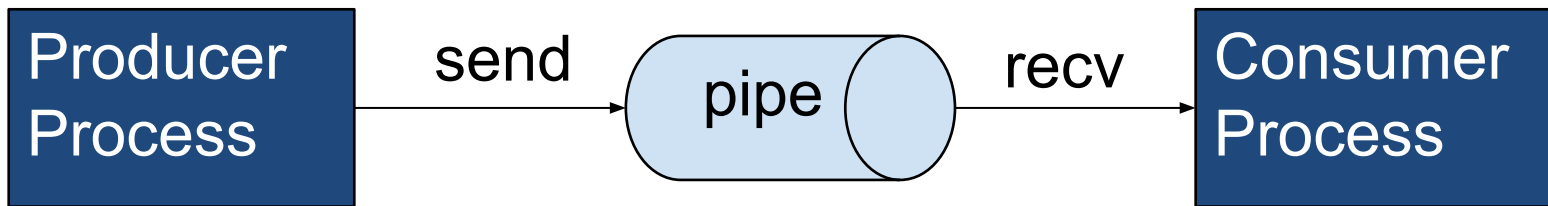
Inter-Process Communication

- Processes **do not** share objects, so...
- Inter-process comm **cannot** be accomplished via a shared object...

Inter-Process Communication

- *Pipe*
 - An operating system (not a Python) feature

Inter-Process Communication



Pipe has a finite size (determined by OS)

Producer process calls `send()`

Blocks when pipe is full

Consumer process calls `recv()`

Blocks when pipe is empty

Inter-Process Communication

- See **prodconprocesses.py**

```
$ python prodconprocesses.py
...
Produced: 95
Consumed: 95
Produced: 96
Consumed: 96
Produced: 97
Consumed: 97
Produced: 98
Consumed: 98
Produced: 99
Consumed: 99
Finished
$
```

Appendix 2:

Inter-Thread Communication

Inter-Thread Communication

- Threads share objects, so...
- Inter-thread comm can be accomplished via a shared object...

Inter-Thread Communication

- Python `Queue` class
 - Semi-thread-safe
 - Designed for inter-thread comm

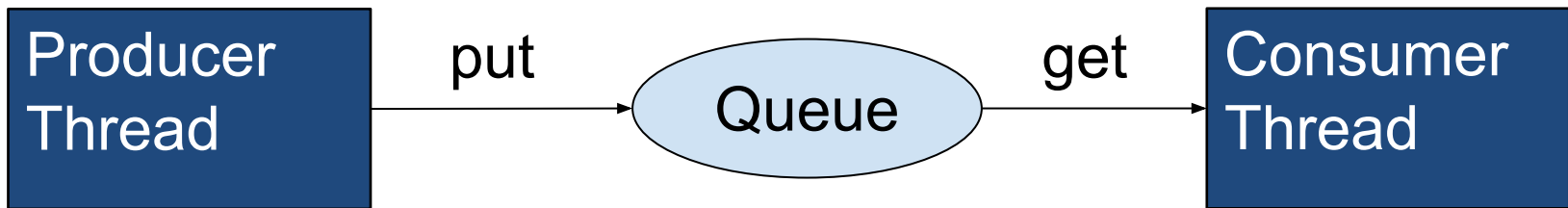
Inter-Thread Communication

- Use case 1:

```
...  
q = queue.Queue()  
...  
q.put(item)  
...  
try:  
    item = q.get(block=False)  
except queue.Empty:  
    # The queue is empty.
```

Queue
object
can contain
an unlimited
number of
items

Inter-Thread Communication



Producer thread calls `put()`

Consumer thread calls `get()`

`get()` throws exception if `Queue` object is empty

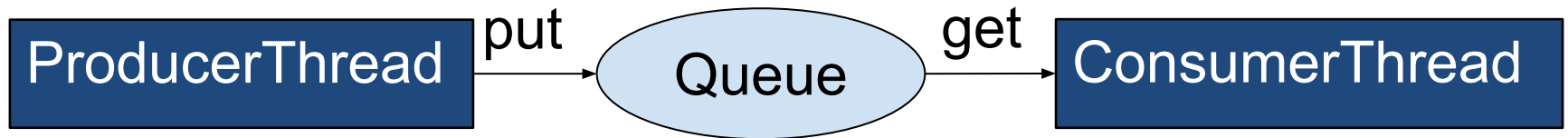
Inter-Thread Communication

- Use case 2:

```
...  
q = queue.Queue(n)  
...  
q.put(item)  
...  
item = q.get()  
...
```

Queue
object can
contain up to
n items

Inter-Thread Communication



Queue object has a finite size

Specified by Python pgm

Producer thread calls `put()`

Waits when Queue object is full

Notifies when finished

Consumer thread calls `get()`

Waits when Queue object is empty

Notifies when finished

Inter-Thread Communication

- See **prodconthreads.py**

```
$ python prodconthreads.py
...
Produced: 97
Consumed: 93
Produced: 98
Consumed: 94
Produced: 99
Consumed: 95
Consumed: 96
Consumed: 97
Consumed: 98
Consumed: 99
Finished
$
```

Inter-Thread Communication

- See **prodconthreads.py** (cont.)
 - Observation: It's a good thing that `Queue` objects are semi-thread-safe

Appendix 3:

Thread Conditions in Java

Thread Conditions in Java

- See **Conditions.java**

```
$ javac Conditions.java
$ java Conditions
1
2
3
4
5
6
7
8
9
10
8
6
4
2
0
Final balance: 0
$
```