The Art of Data Structures

Queues

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CSC 162: The Art of Data Structures
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Agenda

- What Is a Queue?
- The Queue Abstract Data Type
- Implementing a Queue in Python
- Simulation: Hot Potato
- Simulation: Printing Tasks

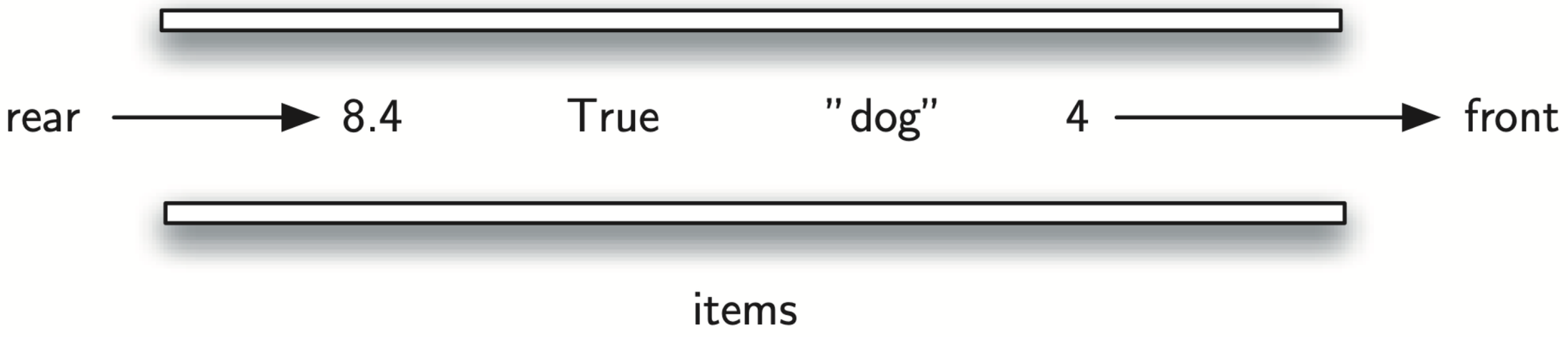
Queues

Queues

- Heavily used for things that take turns "first in, first out" -- FIFO
- Examples:
  - “Ready” list for processes in your computer
  - Incoming messages from the Internet (e.g. to web server)
  - Pending requests to the disk drive

Queues

A Queue of Python Data Objects



Implementation

Implementation
Queue Operations

- `Queue()` creates a new queue that is empty; it needs no parameters and returns an empty queue
- `enqueue(item)` adds a new item to the rear of the queue; it needs the item and returns nothing
- `dequeue()` removes the front item from the queue; it needs no parameters, returns the item and the queue is modified

Implementation
Queue Operations

- `is_empty()` tests to see whether the queue is empty; it needs no parameters and returns a boolean value
- `size()` returns the number of items on the queue; it needs no parameters and returns an integer

Implementation

Queue Operations

Queue Operation	Queue Contents	Return Value
q.is_empty()	[]	TRUE
q.enqueue(4)	[4]	
q.enqueue('dog')	['dog',4]	
q.enqueue(True)	[True,'dog',4]	
q.size()	[True,'dog',4]	3
q.isempty()	[True,'dog',4]	FALSE
q.enqueue(8.4)	[8.4,True,'dog',4]	
q.dequeue()	[8.4,True,'dog']	4
q.dequeue()	[8.4,True]	dog'
q.size()	[8.4,True]	2

Implementation

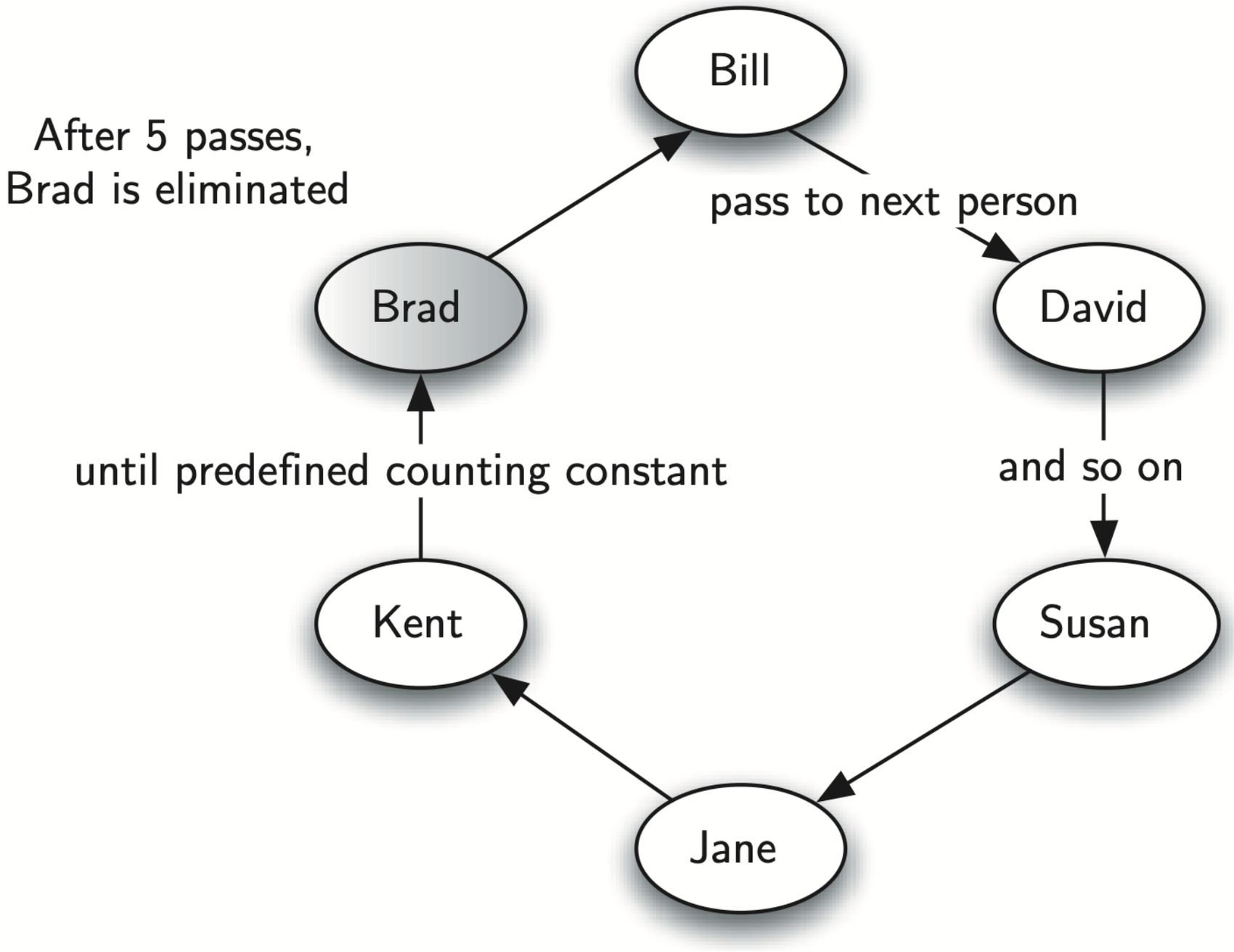
Queue Implementation in Python

```
class Queue:
    def __init__(self):
        self.items = []

    def is_empty(self):
        return self.items == []

def enqueue(self, item):
    self.items.insert(0, item)

def dequeue(self):
    return self.items.pop()

def size(self):
    return len(self.items)
```

Simulation: Hot Potato

Simulation: Hot Potato

A Six Person Game of Hot Potato



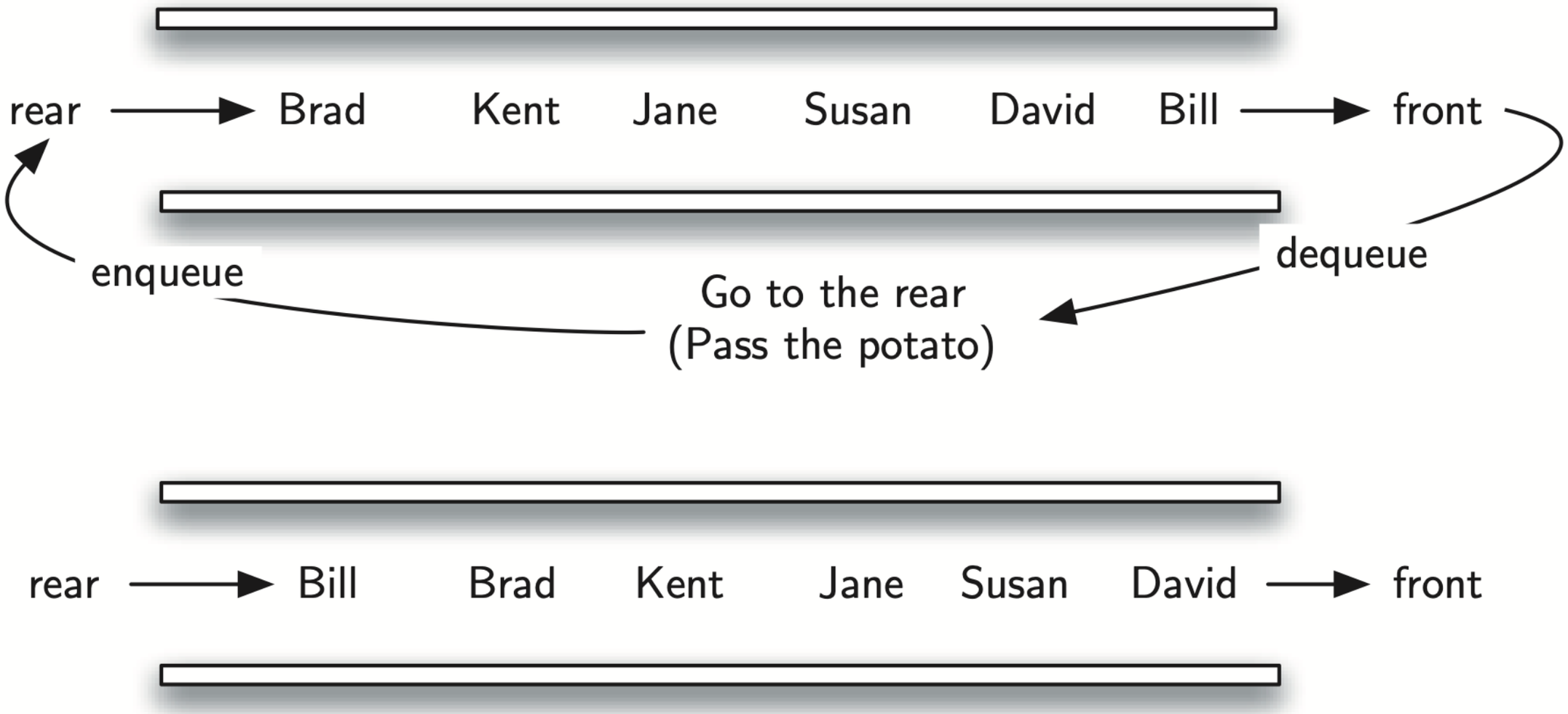
Simulation: Hot Potato

A Six Person Game of Hot Potato

- Whoever has the "potato" when the "music" stops drops out simulation:
  - person at head of queue "has the potato"
  - dequeue and enqueue to simulate passing it to one person

Simulation: Hot Potato

A Queue Implementation of Hot Potato



Simulation: Hot Potato

A Python Implementation

```
def hot_potato(namelist, num):
    simqueue = Queue()

    for name in namelist:
        simqueue.enqueue(name)

    while simqueue.size() > 1:
        for i in range(num):
            simqueue.enqueue(simqueue.dequeue())

        simqueue.dequeue()

    return simqueue.dequeue()
```

Simulation: Hot Potato

A Python Implementation

Round 1: cycles 7 times, producing:
["David", "Susan", "Jane", "Kent", "Brad", "Bill"]
then deletes David

Round 2: cycles 7 times, producing
["Kent", "Brad", "Bill", "Susan", "Jane"]
then deletes Kent

Round 3: cycles 7 times, producing
["Jane", "Brad", "Bill", "Susan"]
then deletes Jane

Round 4: cycles 7 times, producing
["Bill", "Susan", "Brad"]
then deletes Bill

Round 5: cycles 7 times, producing
["Brad", "Susan"]
then deletes Brad
leaving Susan

Simulation: Hot Potato

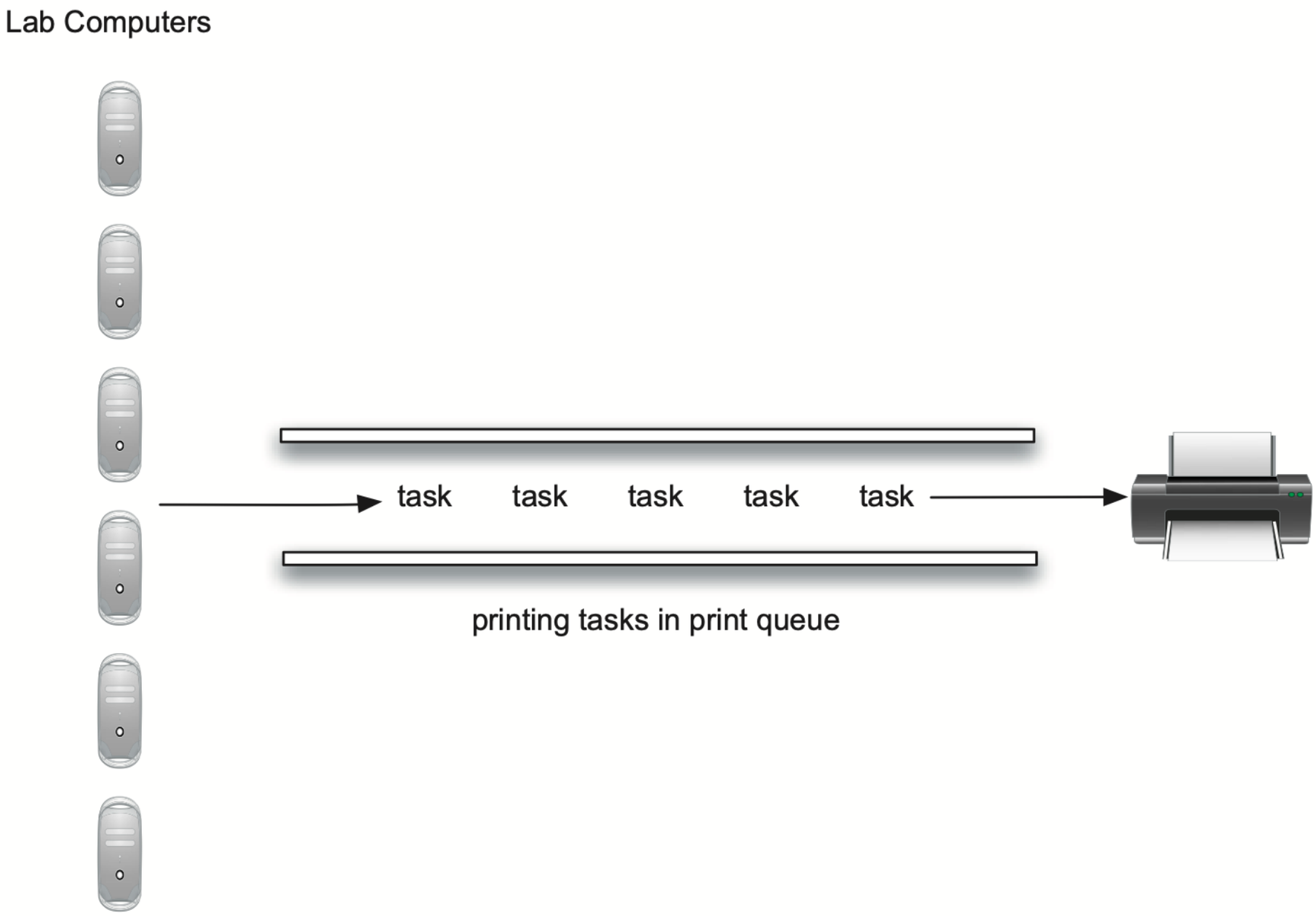
A Python Implementation

- It might make more sense just to have a list, cycle a cursor through it, and eliminate the "person" it points at...

Simulation: Printing Tasks

Simulation: Printing Tasks

Computer Science Lab Printing Queue



Simulation: Printing Tasks

Printer Queue Simulation: `Printer` *Class*

```
class Printer:
    def __init__(self, ppm):
        self.pagerate = ppm
        self.currentTask = None
        self.timeRemaining = 0

    def tick(self):
        if self.currentTask != None:
            self.timeRemaining = self.timeRemaining - 1
            if self.timeRemaining <= 0:
                self.currentTask = None

    def busy(self):
        if self.currentTask != None:
            return True
        else:
            return False

    def startNext(self, newtask):
        self.currentTask = newtask
        self.timeRemaining = newtask.getPages() * 60/self.pagerate
```

Simulation: Printing Tasks

Printer Queue Simulation: `Printer` *Class*

```
import random

class Task:
    def __init__(self,time):
        self.timestamp = time
        self.pages = random.randrange(1,21)

    def getStamp(self):
        return self.timestamp

    def getPages(self):
        return self.pages

    def waitTime(self, currenttime):
        return currenttime - self.timestamp
```

Simulation: Printing Tasks

Printer Queue Simulation: `Printer` *Class*

```
import random

def simulation(numSeconds, pagesPerMinute):

    labprinter = Printer(pagesPerMinute)
    printQueue = Queue()
    waitingtimes = []

    for currentSecond in range(numSeconds):

      if newPrintTask():
         task = Task(currentSecond)
         printQueue.enqueue(task)

      if (not labprinter.busy()) and (not printQueue.isEmpty()):
        nexttask = printQueue.dequeue()
        waitingtimes.append(nexttask.waitTime(currentSecond))
        labprinter.startNext(nexttask)

      labprinter.tick()

    averageWait=sum(waitingtimes)/len(waitingtimes)
    print("Average Wait %6.2f secs %3d tasks remaining."%
(averageWait,printQueue.size()))
```

Simulation: Printing Tasks

Printer Queue Simulation: `Printer` *Class*

```
def newPrintTask():
    num = random.randrange(1,181)
    if num == 180:
        return True
    else:
        return False

for i in range(10):
    simulation(3600,5)
```

Simulation: Printing Tasks
Discussion

- This simulation could be used to answer questions such as:
- Will the available printer keep up if enrollment increases?
- What if the size of the average print task decreases since Python is such a powerful language and programs tend to be much shorter?

Simulation: Printing Tasks
Discussion

- However, it is important to remember that a simulation is only as good as the assumptions that are used to build it
- Real data about the number of print tasks per hour and the number of students per hour is necessary to construct a robust simulation
- Also, the printer might jam sometimes

Questions?