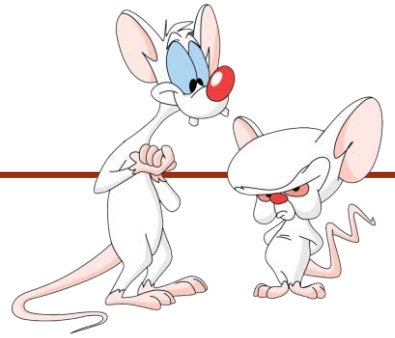
COMP 250
INTRODUCTION TO COMPUTER SCIENCE

Week 7-2 : Queues

Giulia Alberini, Fall 2020
Slides adapted from Michael Langer's

WHAT ARE WE GOING TO DO IN THIS VIDEO?



- Queues

ADT (ABSTRACT DATA TYPE)

- List

  add(i, e), remove(i), get(i), set(i), ...

- Stack

  push(e) , pop(), ..

- Queue

  enqueue(e), dequeue()

QUEUE

dequeue
(remove from front)

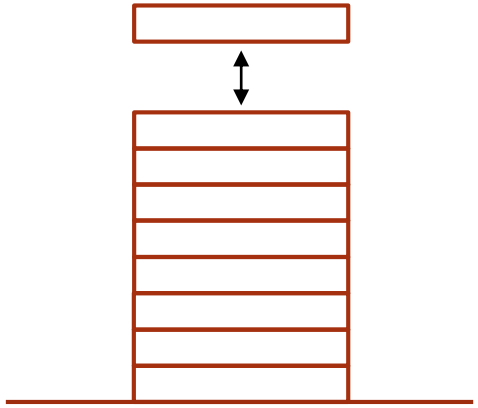
enqueue
(add at back)

e.g. Server

clients

EXAMPLES

- keyboard buffer
- CPU processes (applications do not run in parallel)
- web server
- students in the zoom waiting room
- …

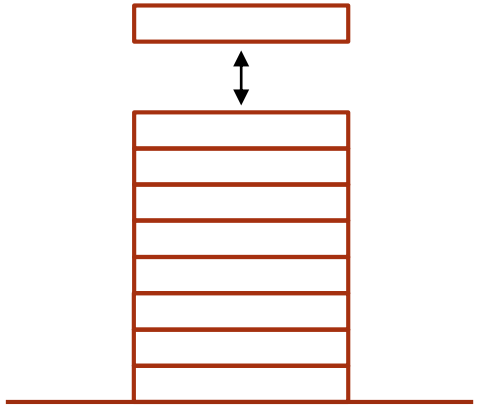


Stack

push(e)

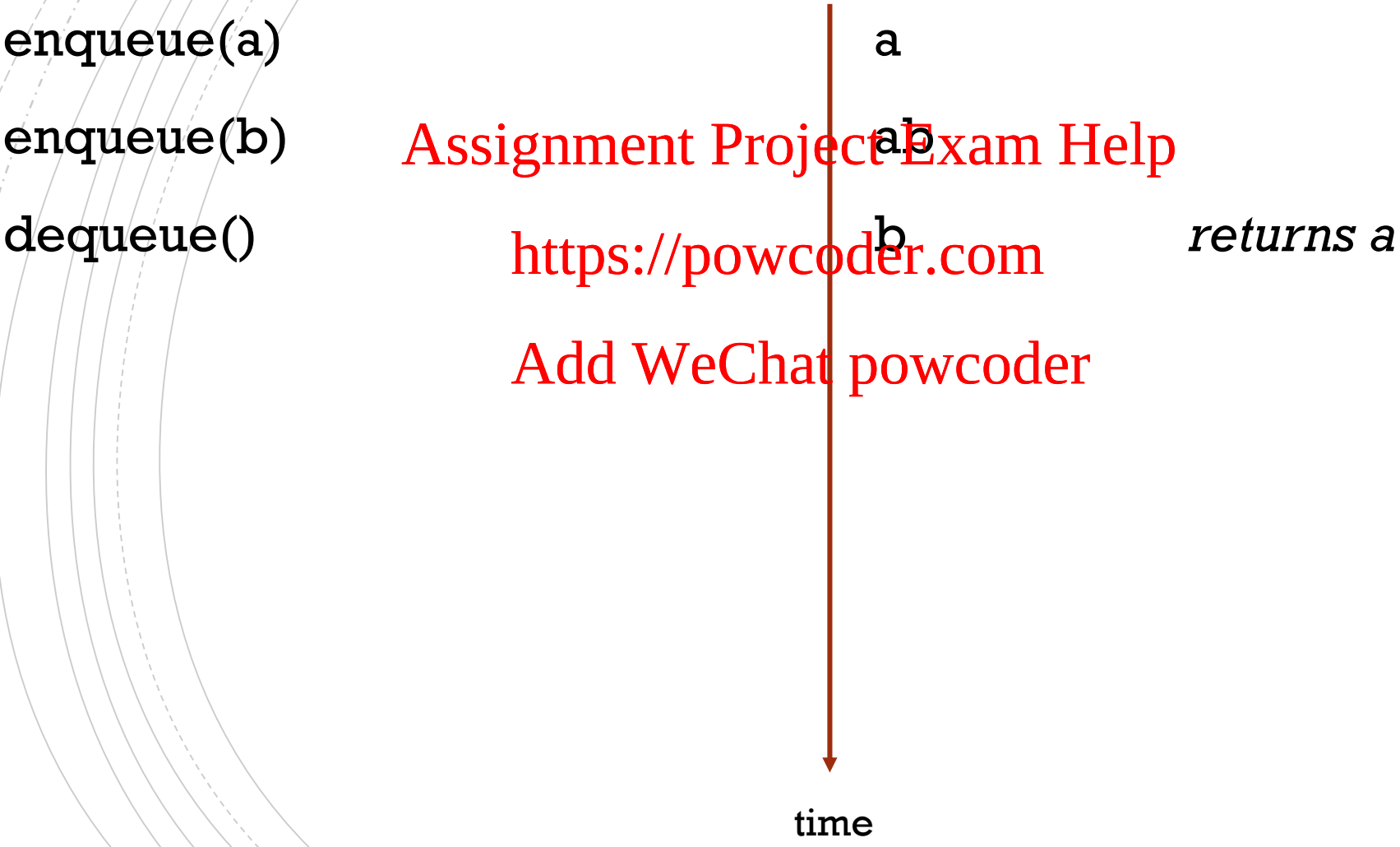
pop()

LIFO
(last in, first out)

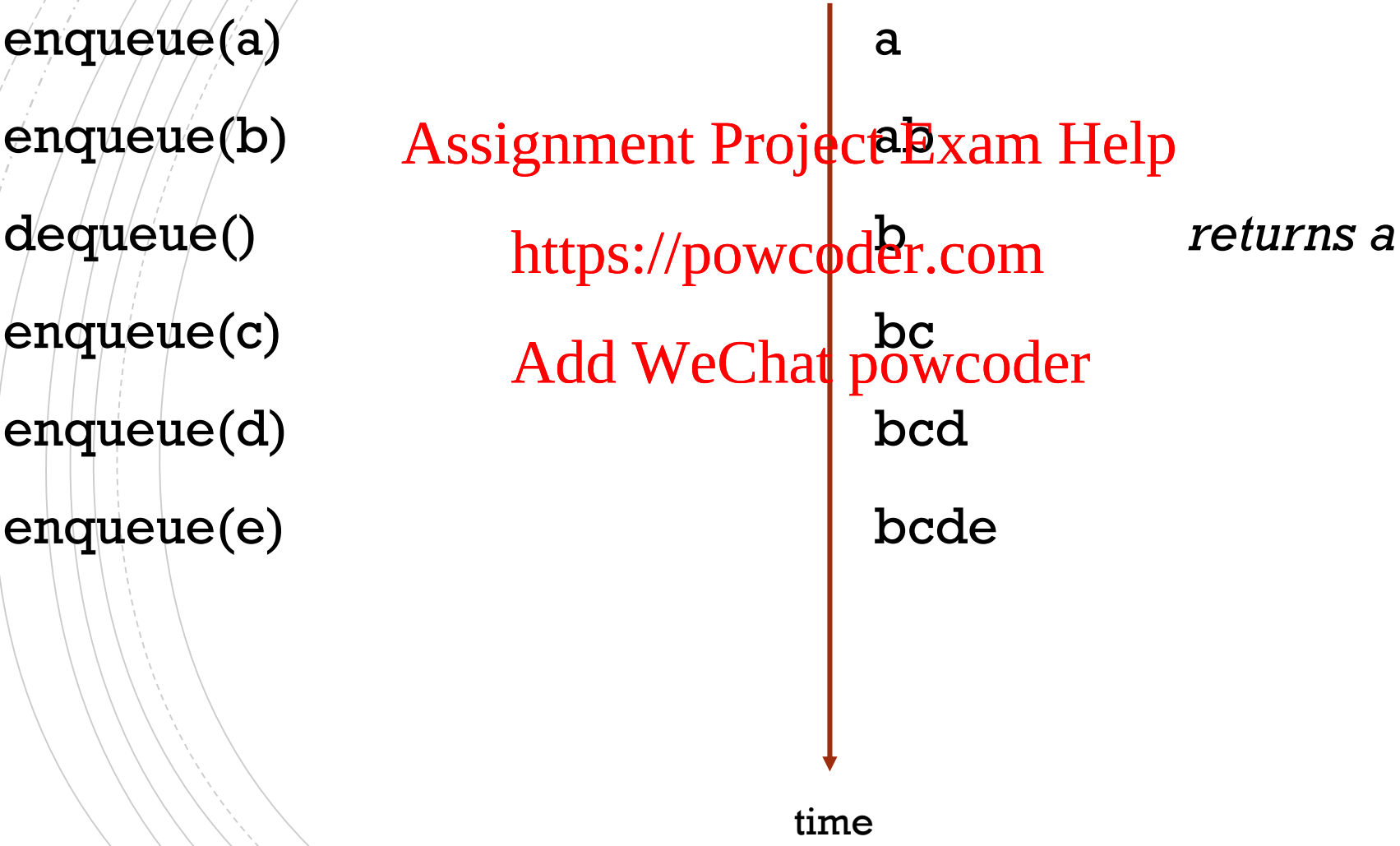


Stack	Queue
push(e)	enqueue(e)
pop()	dequeue()
LIFO (last in, first out)	FIFO (first in, first out) "first come, first serve"

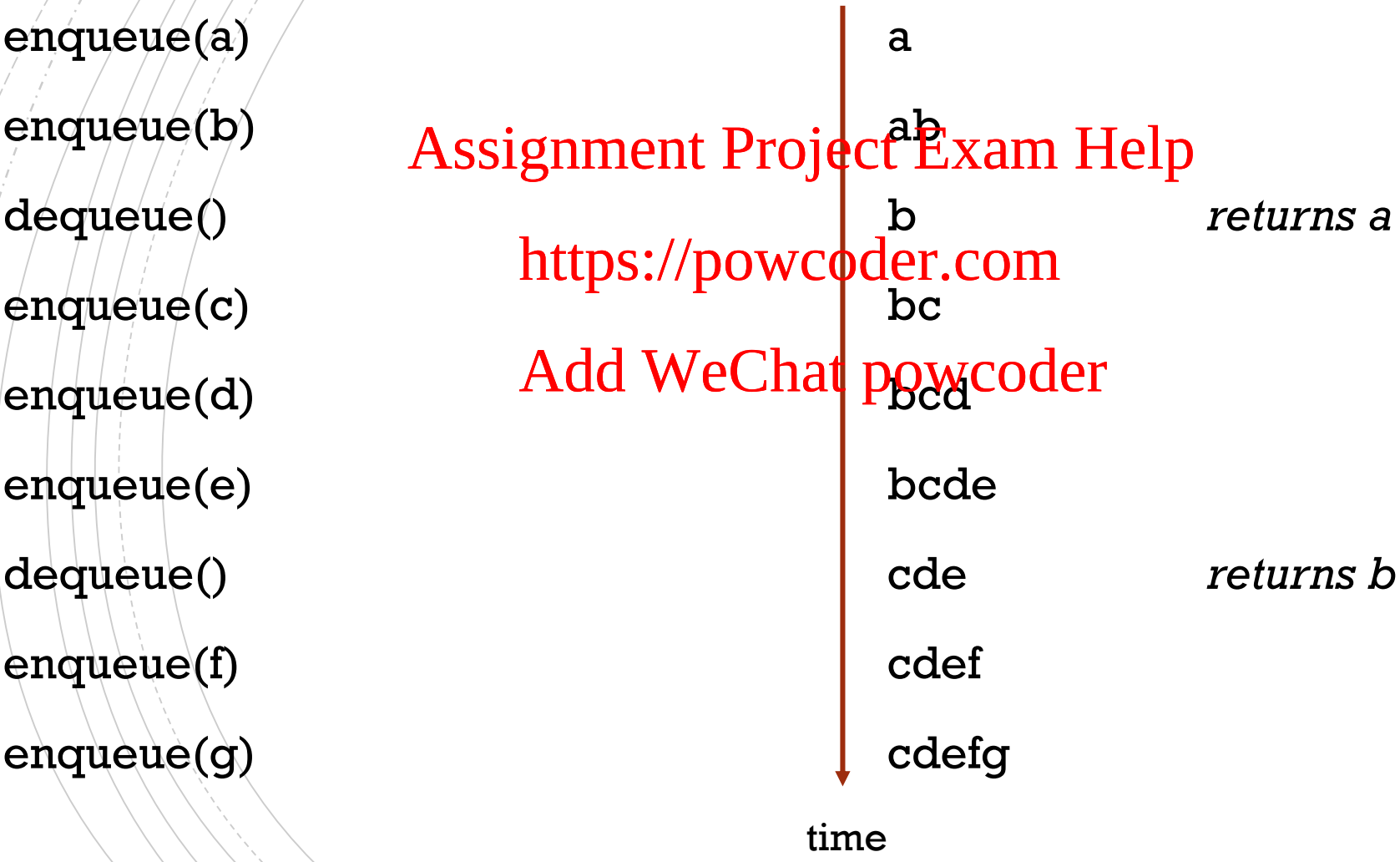
QUEUE EXAMPLE



QUEUE EXAMPLE



QUEUE EXAMPLE



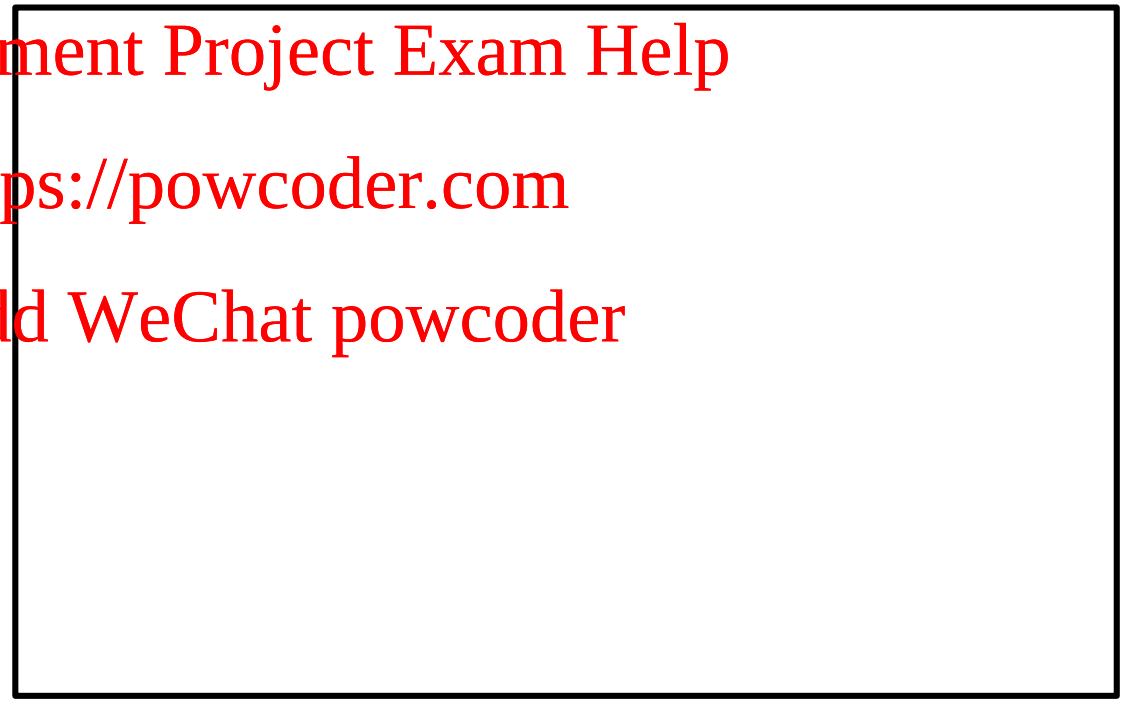
HOW TO IMPLEMENT A QUEUE?

enqueue(e) dequeue()

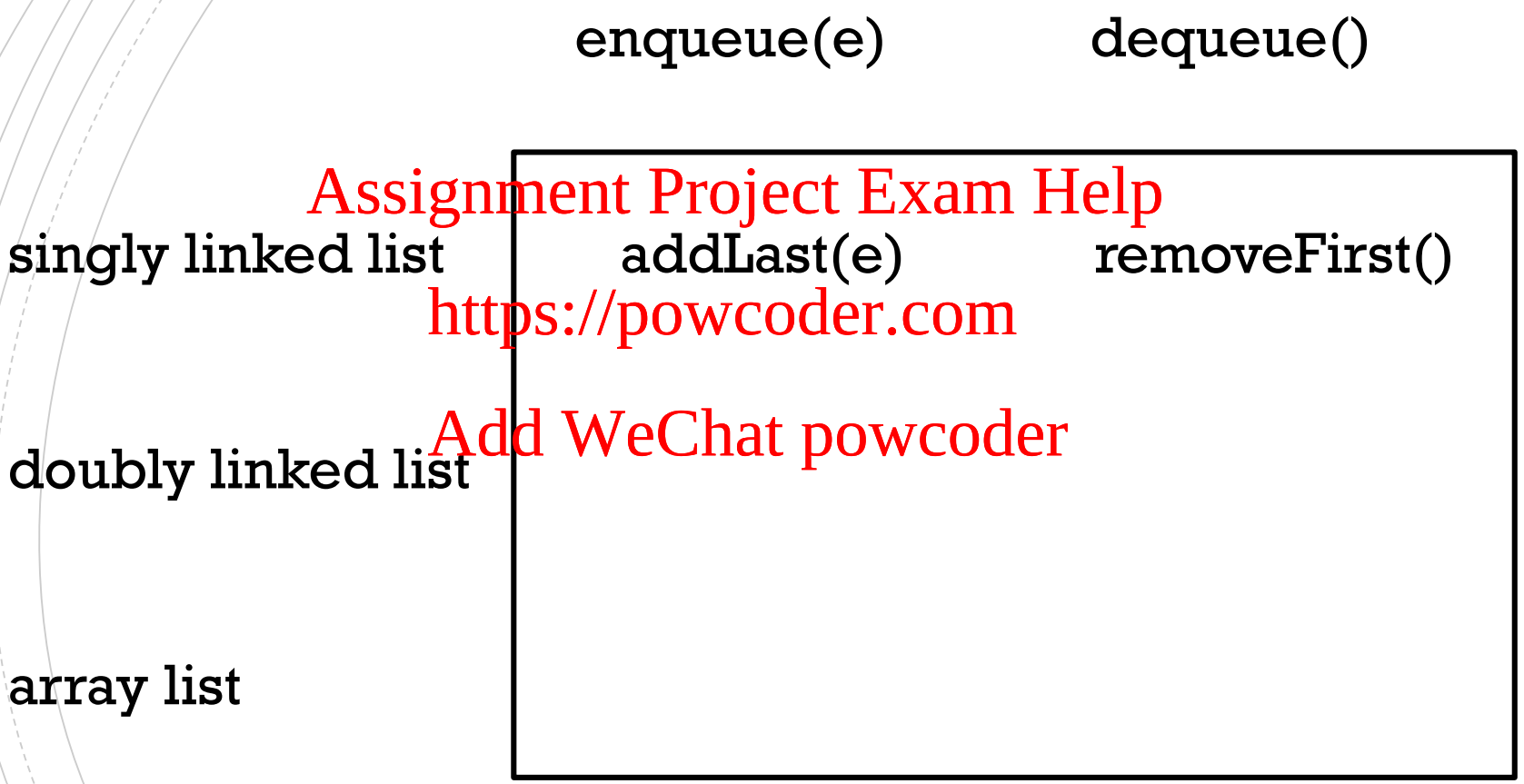
singly linked list

doubly linked list

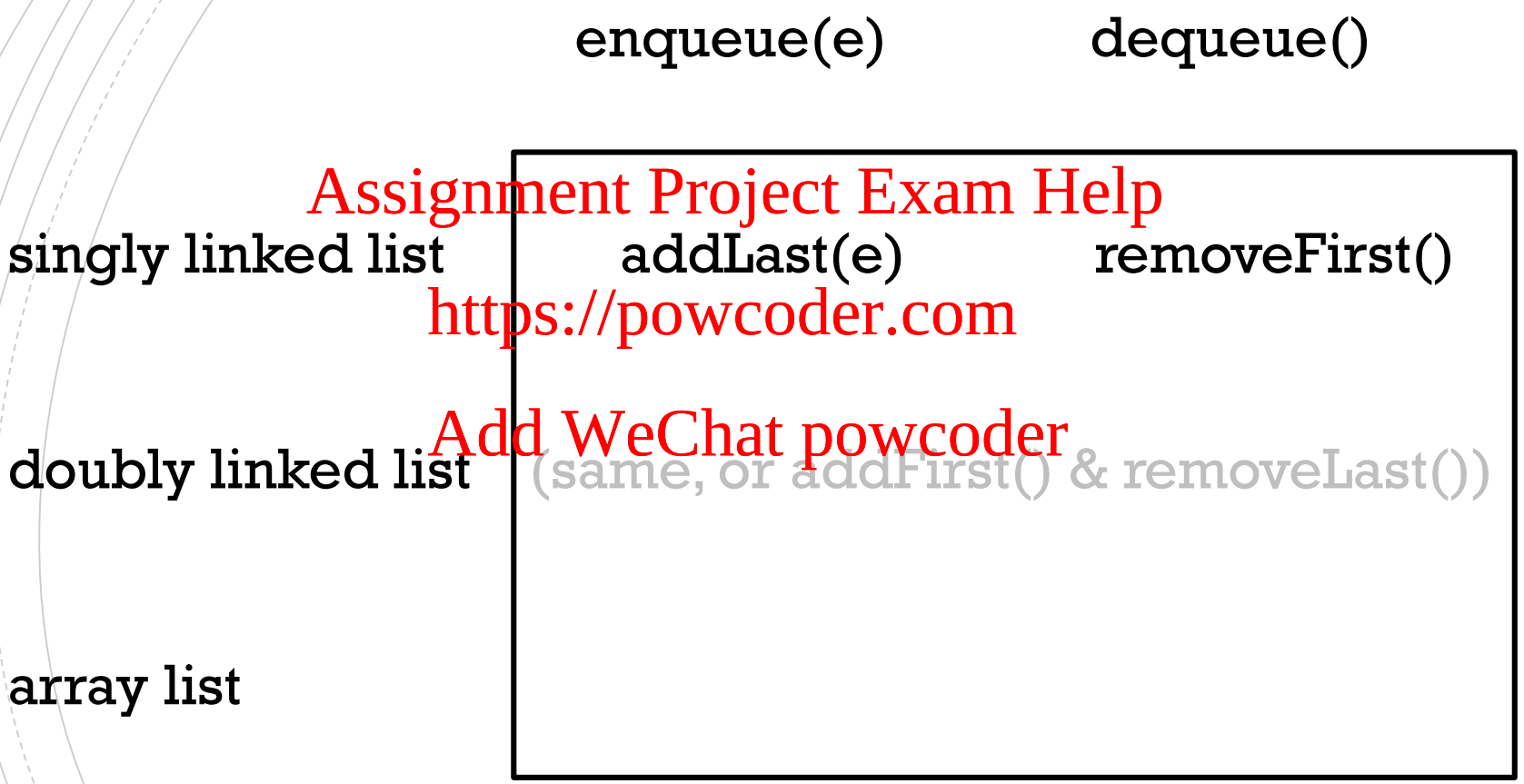
array list



HOW TO IMPLEMENT A QUEUE?



HOW TO IMPLEMENT A QUEUE?

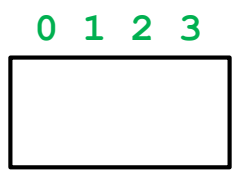


HOW TO IMPLEMENT A QUEUE?

	enqueue(e)	dequeue()
singly linked list	addLast(e)	removeFirst()
doubly linked list	(same, or addFirst() & removeLast())	
array list	addLast(e)	**removeFirst()**

SLOW!

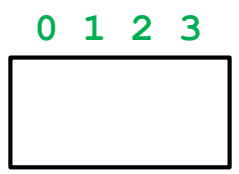
IMPLEMENTING A QUEUE WITH AN ARRAY LIST (BAD)



length = 4

enqueue(a)	a---	
enqueue(b)	ab--	
dequeue( )	b---	Requires shift

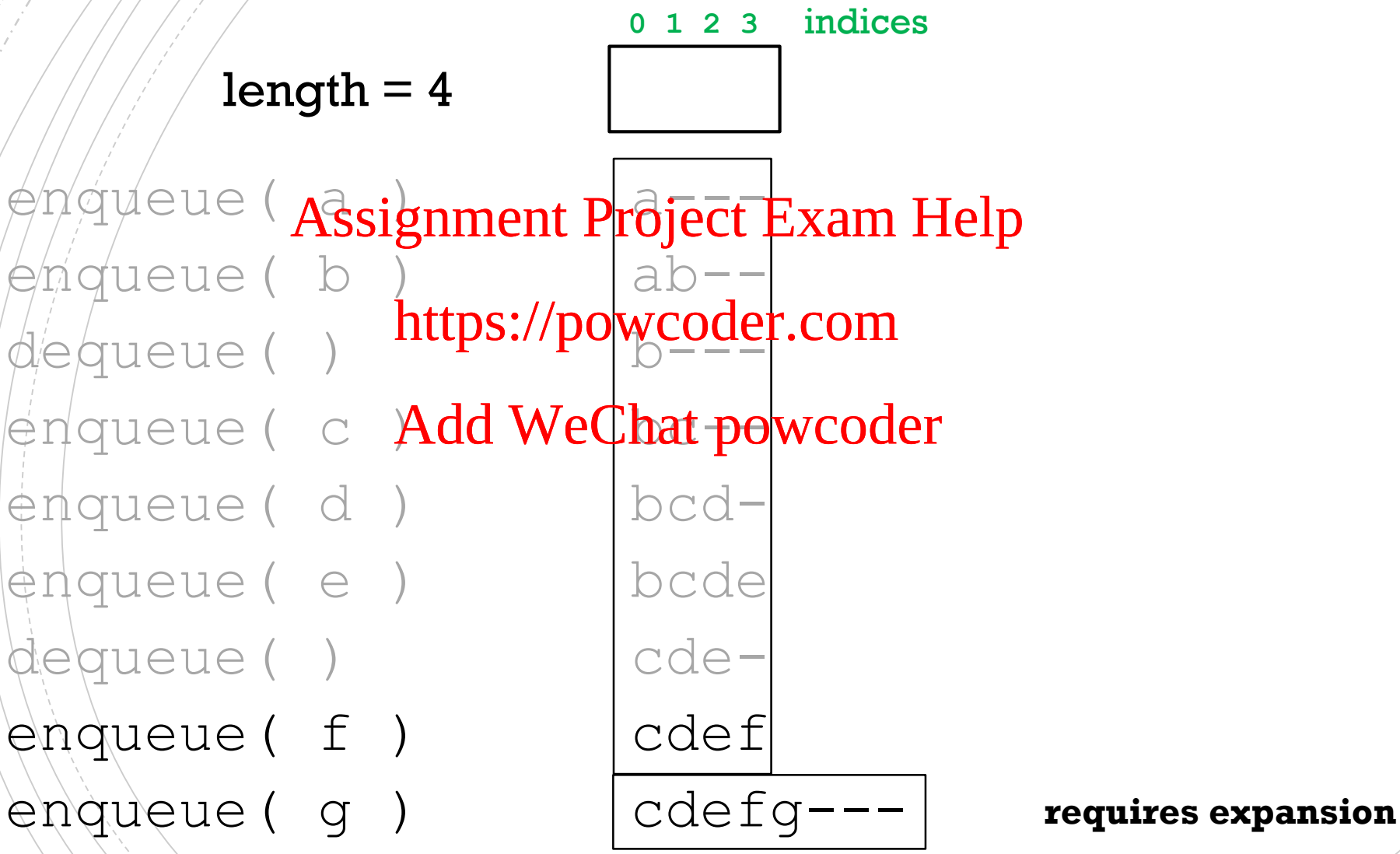
IMPLEMENTING A QUEUE WITH AN ARRAY LIST (BAD)



length = 4

enqueue(a)	a---	
enqueue(b)	ab--	
dequeue( )	b---	Requires shift
enqueue(c)	bc--	
enqueue(d)	bcd-	
enqueue(e)	bcde	
dequeue( )	cde-	Requires shift

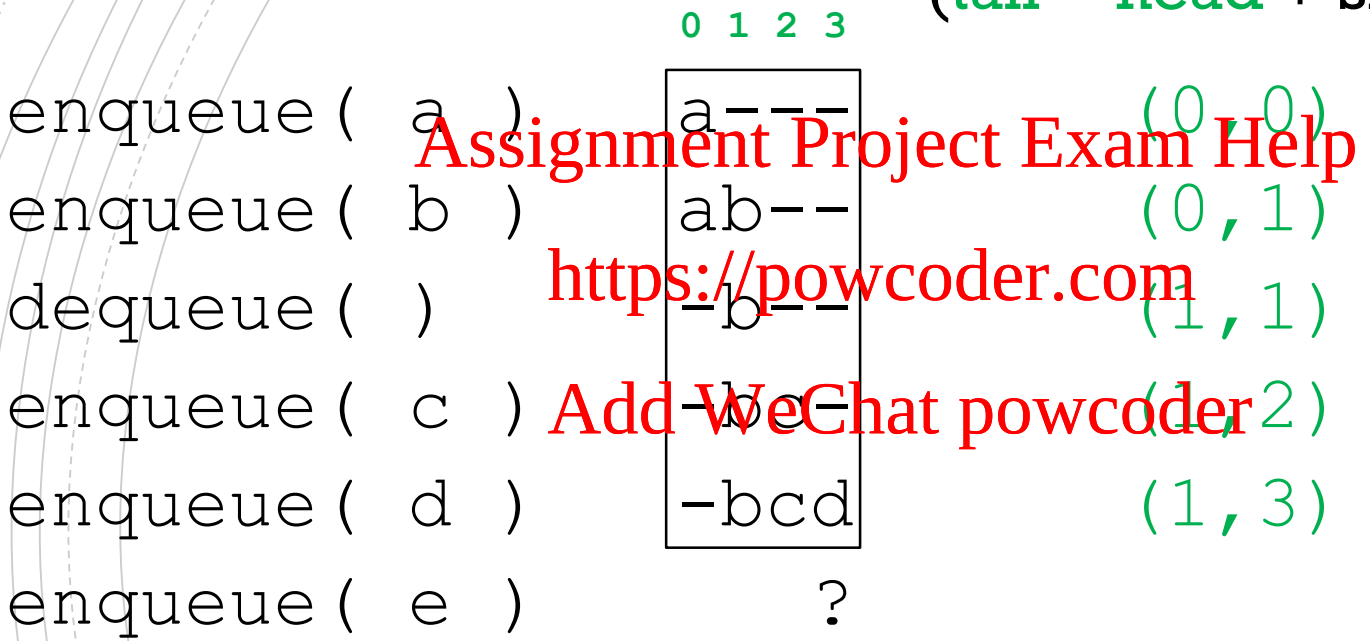
IMPLEMENTING A QUEUE WITH AN ARRAY LIST (BAD)



requires expansion

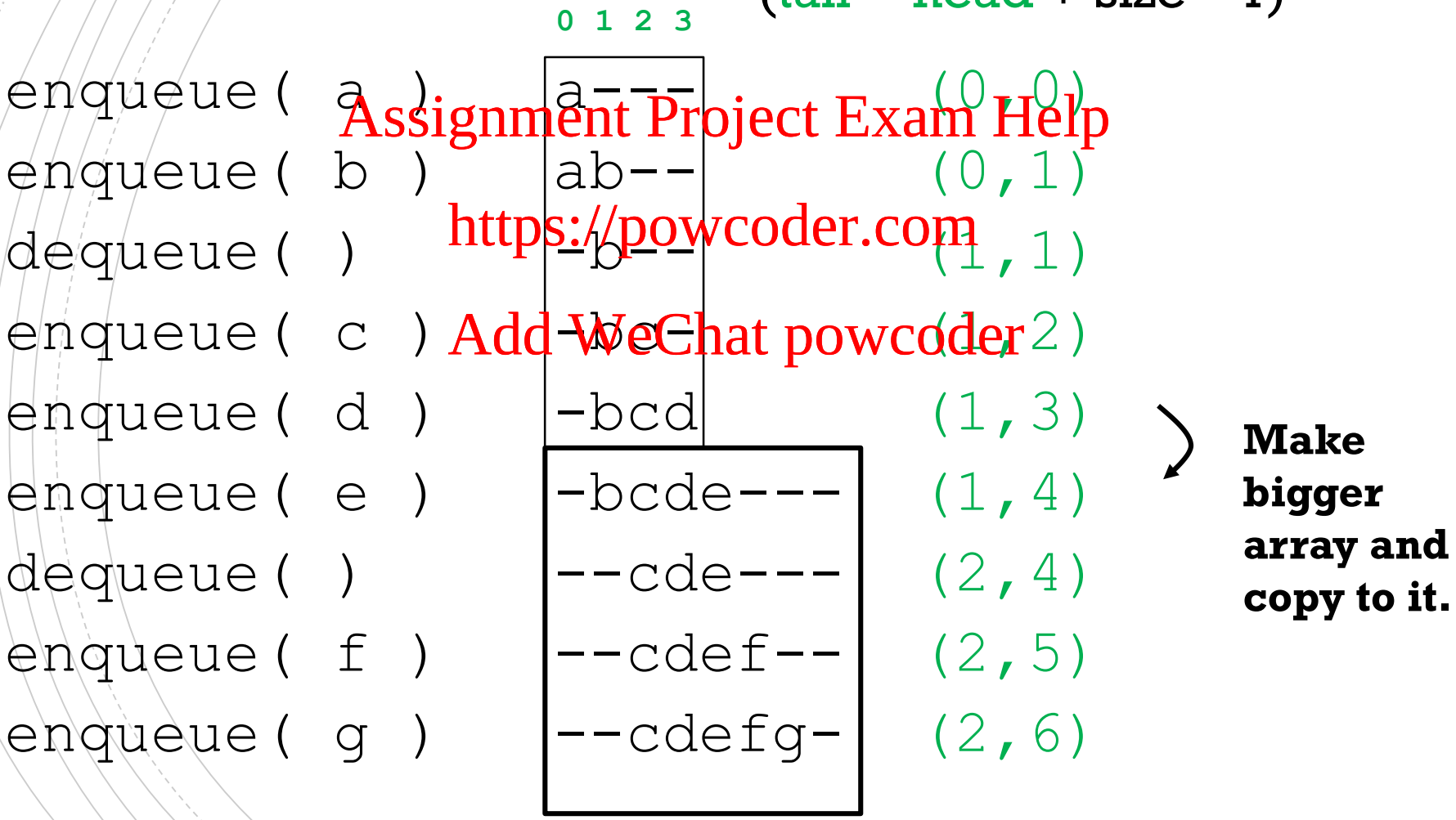
IMPLEMENTING A QUEUE WITH AN EXPANDING ARRAY (ALSO BAD)

Use head and tail indices
(tail = head + size – 1)



IMPLEMENTING A QUEUE WITH AN EXPANDING ARRAY (ALSO BAD)

Use head and tail indices
(tail = head + size – 1)



IMPLEMENTING A QUEUE WITH AN EXPANDING ARRAY

- to dequeue: retrieve the element at head and increase the index head
- to enqueue: add the element at tail + 1

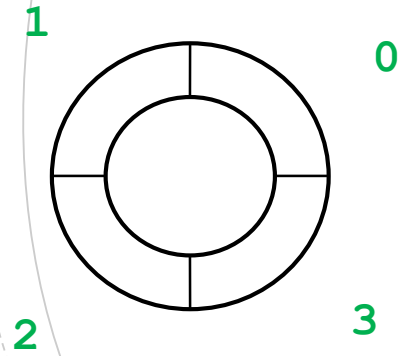
An expanding array is an inefficient usage of space!

A better idea is…

CIRCULAR ARRAY

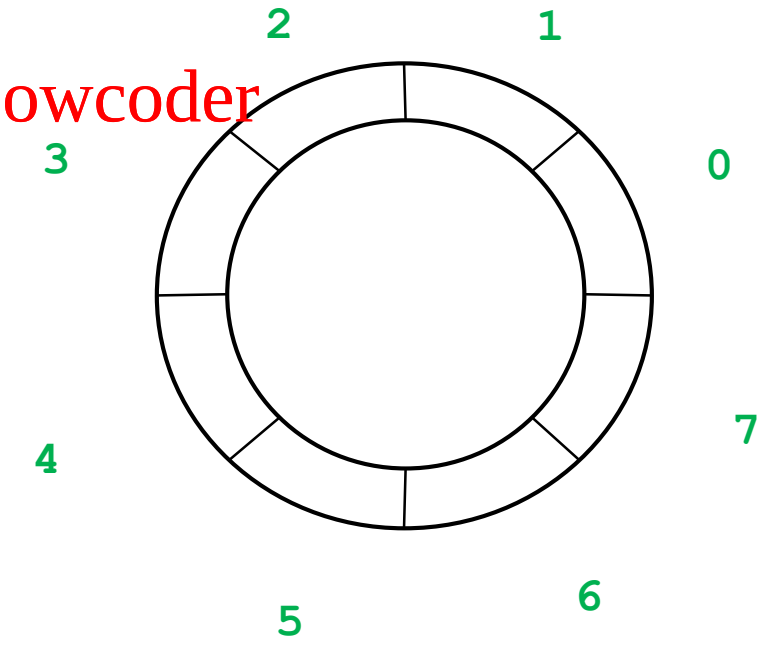
length = 4

0123



length = 8

01234567



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

tail = (head + size – 1) mod length

```
enqueue( a )
enqueue( b )
dequeue() ?
```

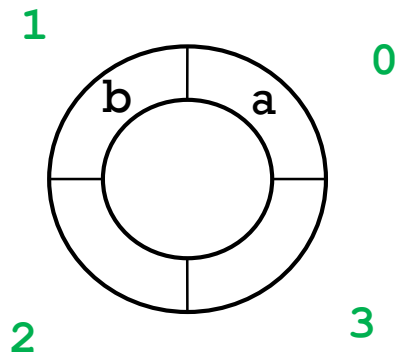

tail

head

0123

ab--

head=0 tail=1



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

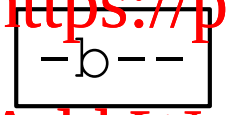
tail = (head + size – 1) mod length

```
enqueue( a )
enqueue( b )
dequeue()
enqueue( c ) ?
```

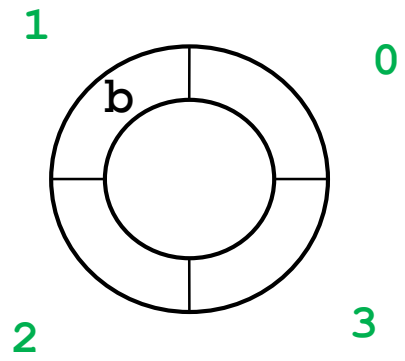

head

tail

0123



head=1 tail=1



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

tail = (head + size – 1) mod length

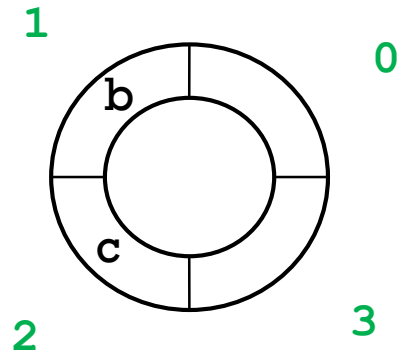
```
enqueue( a )
enqueue( b )
dequeue()
enqueue( c )
enqueue( d ) ?
```


head

0123

-bc-

head=1 tail=2



tail

IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

tail = (head + size – 1) mod length

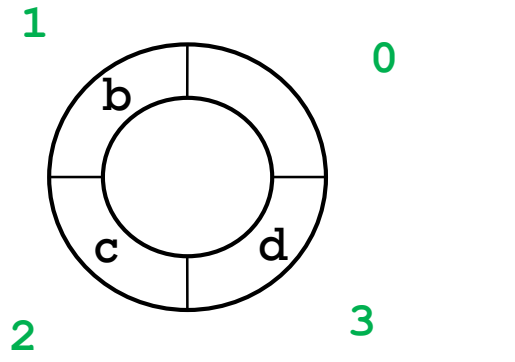
```
enqueue( a )
enqueue( b )
dequeue()
enqueue( c )
enqueue( d )
enqueue( e ) ?
```


head

0123

-bcd

head=1 tail=3



tail

IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

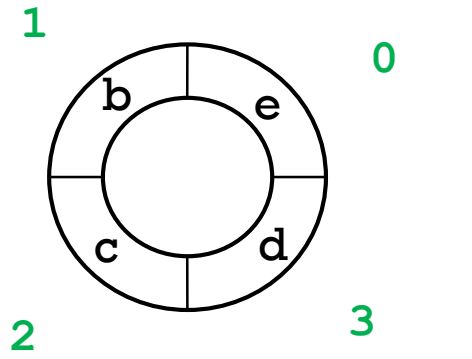
```
enqueue( a )
enqueue( b )
dequeue()
enqueue( c )
enqueue( d )
enqueue( e )
dequeue() ?
```

tail = (head + size – 1) mod length

0123

ebcd

head=1 tail=0

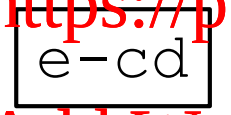


IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

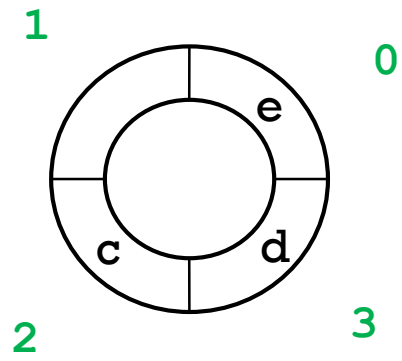
tail = (head + size – 1) mod length

```
enqueue( a )
enqueue( b )
dequeue()
enqueue( c )
enqueue( d )
enqueue( e )
dequeue()
```


0123



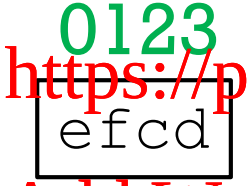
head=2 tail=0



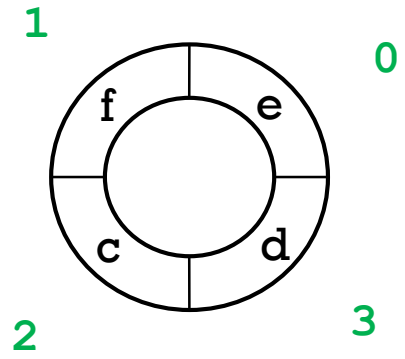
IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

tail = (head + size – 1) mod length

```
enqueue( a )
enqueue( b )
dequeue()
enqueue( c )
enqueue( d )
enqueue( e )
dequeue()
enqueue( f )
enqueue( g ) ?
```

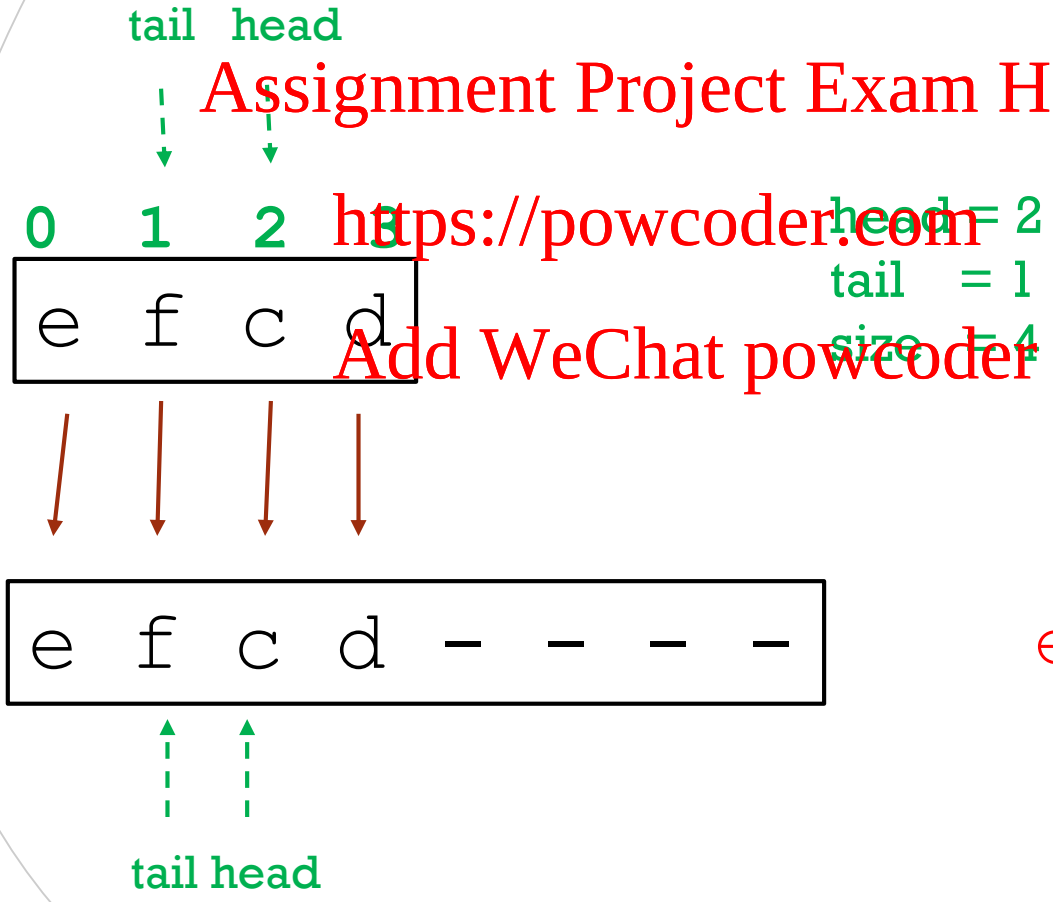



head=2 tail=1



INCREASE THE LENGTH OF THE ARRAY AND COPY

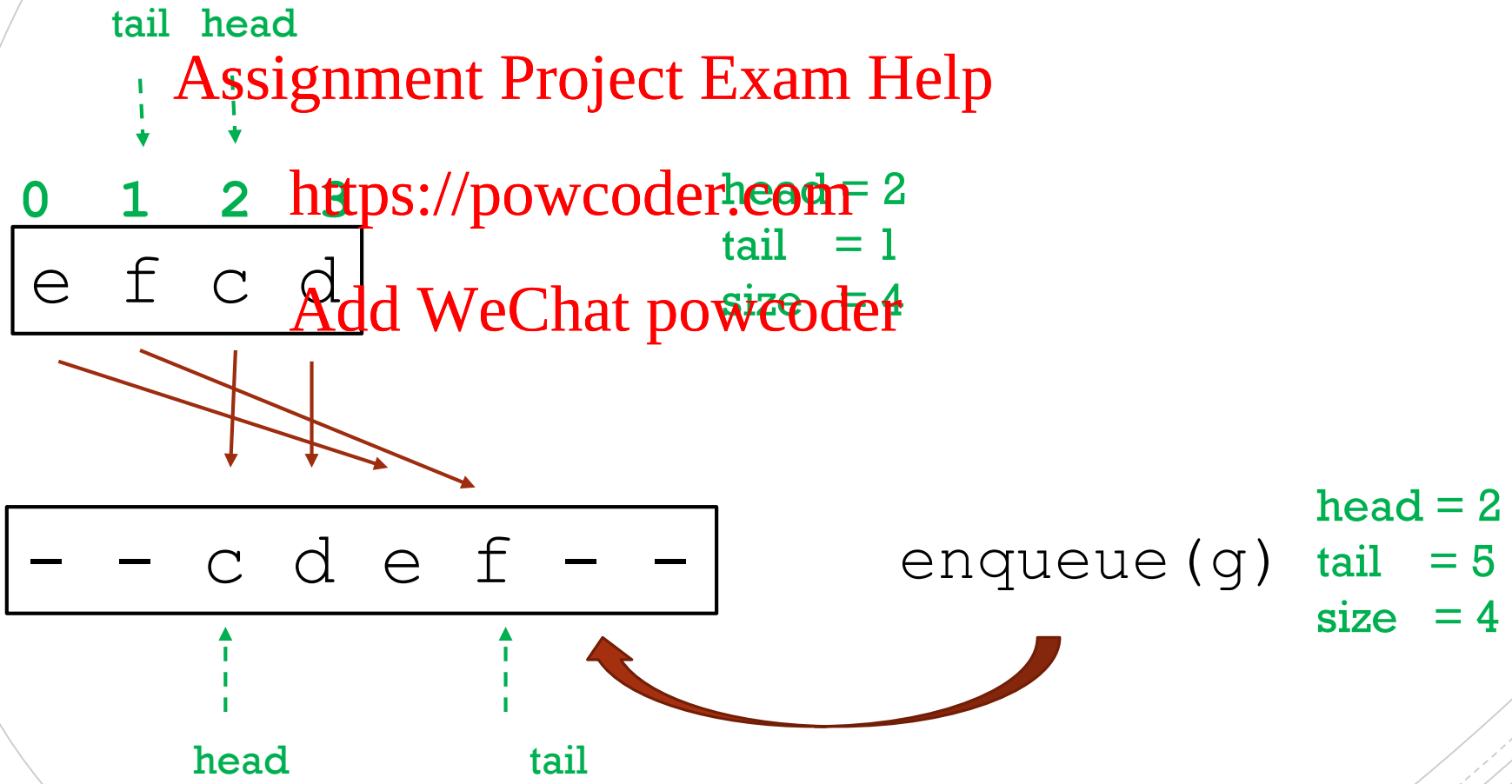
Be careful, on how you copy! The following would not work:



enqueue(g) ?

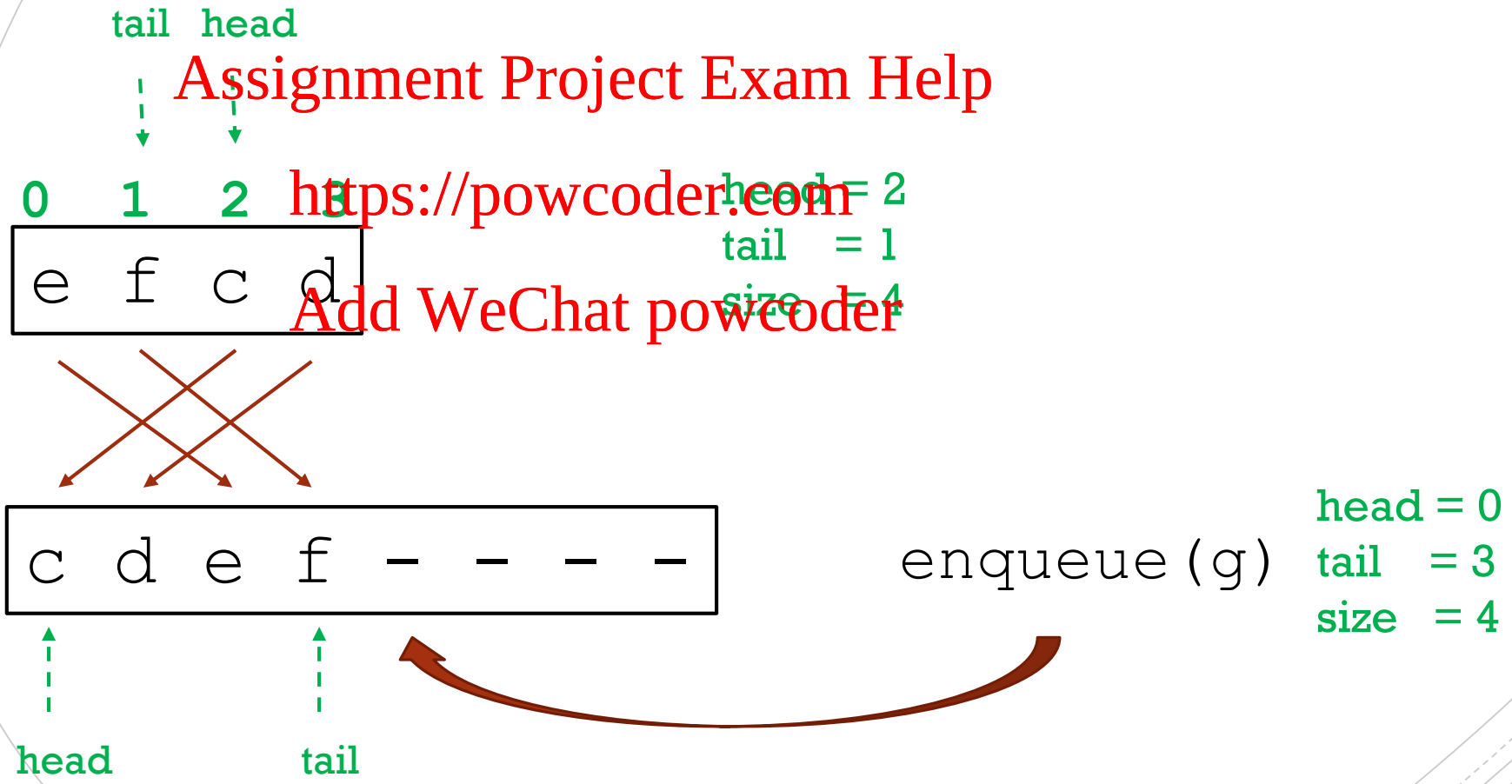
INCREASE THE LENGTH OF THE ARRAY AND COPY

Instead you can copy so that the head remains in the same position.



INCREASE THE LENGTH OF THE ARRAY AND COPY

OR you can copy so that the head moves to position 0.



ENQUEUE(e)

```
enqueue( element ){
   if (size == queue.length)  {
      //  increase length of array
      create a bigger array tmp[ ]    //  e.g. 2*length
      for i = 0  to queue.length - 1
         tmp[i] = queue[(head + i) mod queue.length]
      head = 0
      queue = tmp
   }
   queue[(head + size) mod length] = element
   size++
}
```


Note that we don't have a tail variable here. Instead, recall that *tail = (head + size -1) mod length*, and note that the new element is added in position *(tail + 1) mod length*.

DEQUEUE()

```
dequeue() {
    if size <= 0
        raise error

    element = queue[head]
    size = size - 1
    head = (head + 1) mod length
    return element
}
```

WHAT IF SIZE IS 0?

What is the relation between head and tail when size is equal to 0?

tail = (head + size – 1) mod length

array	(head, tail, size)
Initial state ____	(0, 3, 0)

WHAT IF SIZE IS 0?

What is the relation between head and tail when size is equal to 0?

tail = (head + size – 1) % length

	array	(head, tail, size)
Initial state	----	(0, 3, 0)
enqueue(a)	a---	(0, 0, 1)
enqueue(b)	ab--	(0, 1, 2)
dequeue()	-b--	(1, 1, 1)
dequeue()	----	(2, 1, 0)

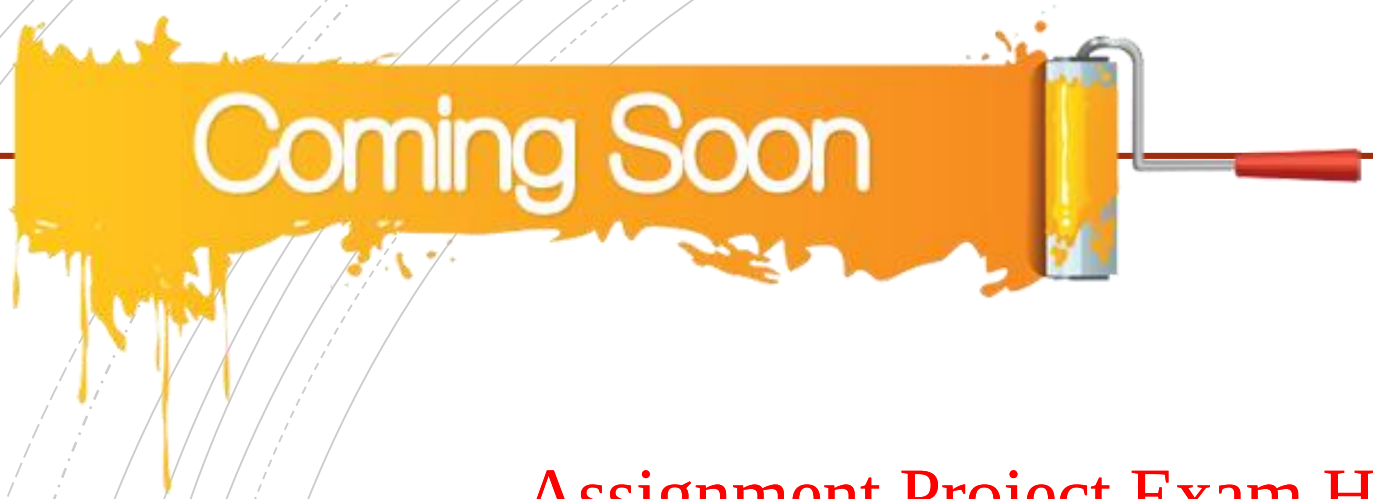
tail head

ADT (ABSTRACT DATA TYPE)

Defines a data type by the values and operations from the user's perspective only. It ignores the details of the implementation.

Examples:

- list
- stack
- queue
- …



In the next videos:

- Back to Java: interfaces!