CS2040 Lab 5
Hashing

Take-Home Assignment 2a – Join Strings

- Use custom linked list implementation (TailedLinkedList.java suffices)
- Use ArrayList<TailedLinkedList> (or a regular TailedLinkedList[] array)
- When concatenating string b to a (ie. string is a + b), set tail node of a to point to head node of b
- Update tail node pointer of a to tail node of b
- No need to set b to null in the array after concatenation, as b is never referenced again (but you can do so if you want)
- Use StringBuffer or StringBuilder when constructing the final answer, or just print directly without creating a string

Take-Home Assignment 2b – Long Wait

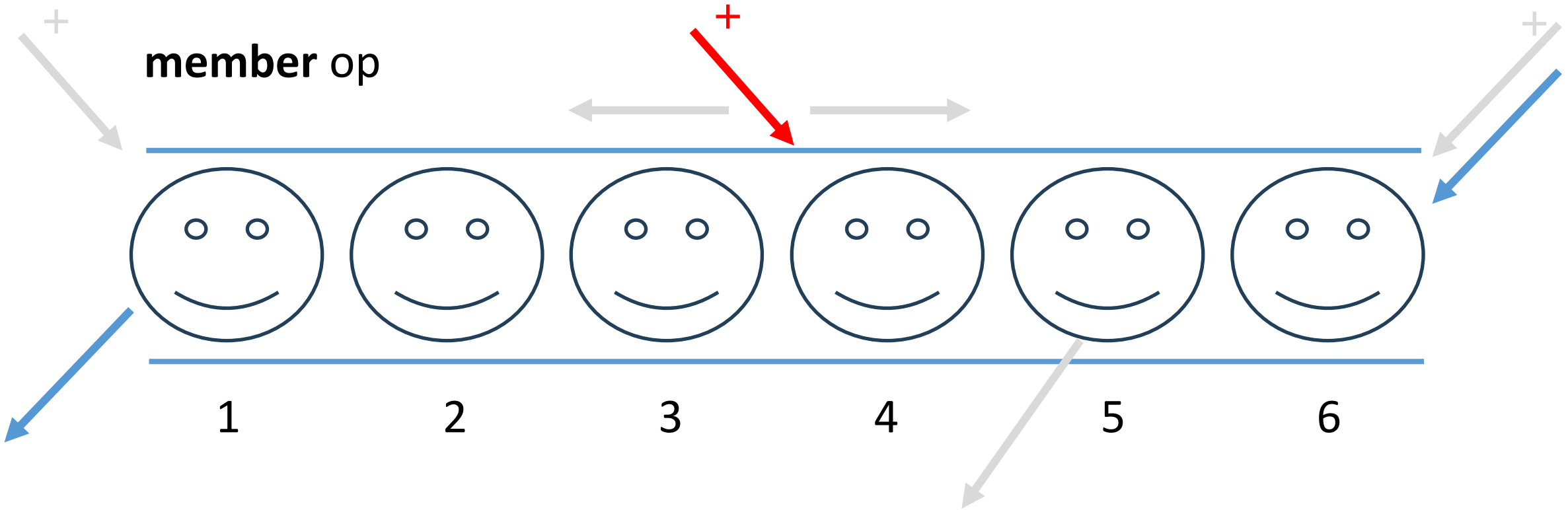
- All operations need to run in O(1) time
- For access to an element in O(1) time (**findID pos** operation), this suggests the use of an array
- However, Java does **NOT** have array-based deque that supports **random access**
  - see API for java.util.ArrayDeque
- Build an array-based Deque yourself!

Take-Home Assignment 2b – Long Wait

- Pushing to the back can easily (**queue x**) be done in O(1) time too
- For adding to the front (**vip x**), instead of fixing index 0 as the front, allow for the front index to change
- This can be accomplished by using a circular array, with head and tail indices, as well as size attribute

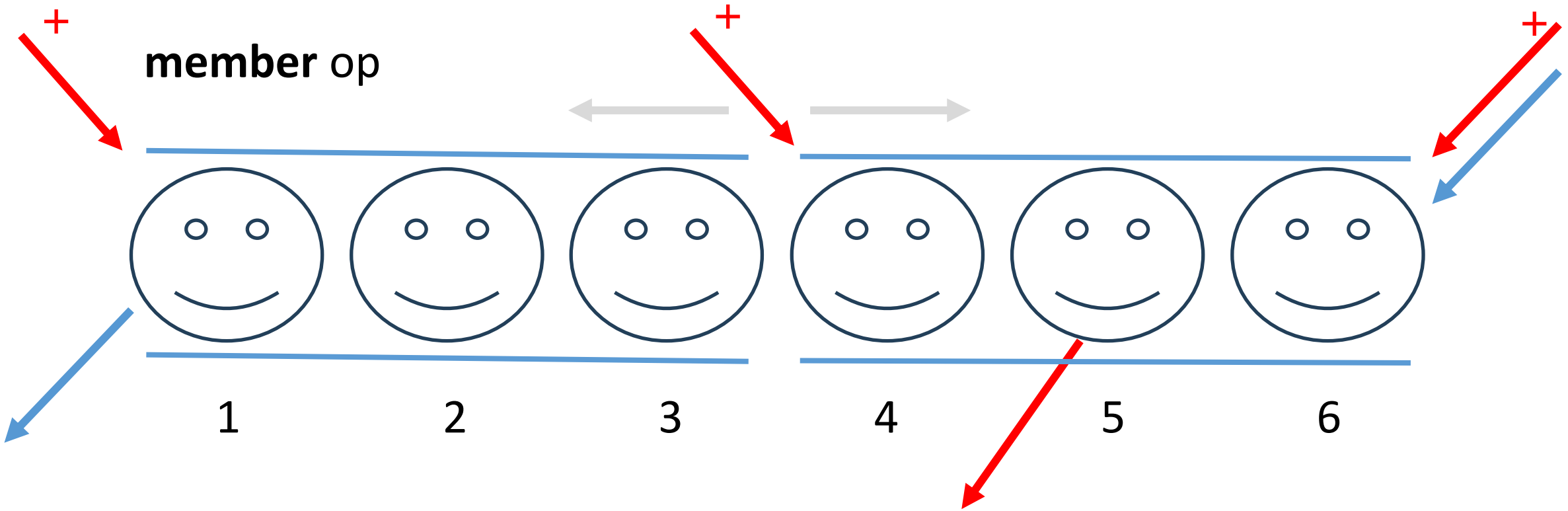
Take-Home Assignment 2b – Long Wait

- How to insert to middle (**member x**)?
- Split into two circular arrays
  - one contains the front “half” (array 1), i.e. the front **K** people in the queue
  - the other contains the back “half” of the ADT (array 2), i.e. **K + 1** onwards
- Balance out the number of elements between the two arrays after every insert operation if necessary, so the “middle” is easily accessible
  - Should never need to move more than 1 element between the two arrays, so this is still O(1)
- For a **findID** operation using 2 arrays, access the n^{th} element in array 1, or the $(n-(\text{size of array 1})^{th})$ element in array 2 if n exceeds the size of array 1



Deque only has front and back

Divide “queue” into 2 Deques!



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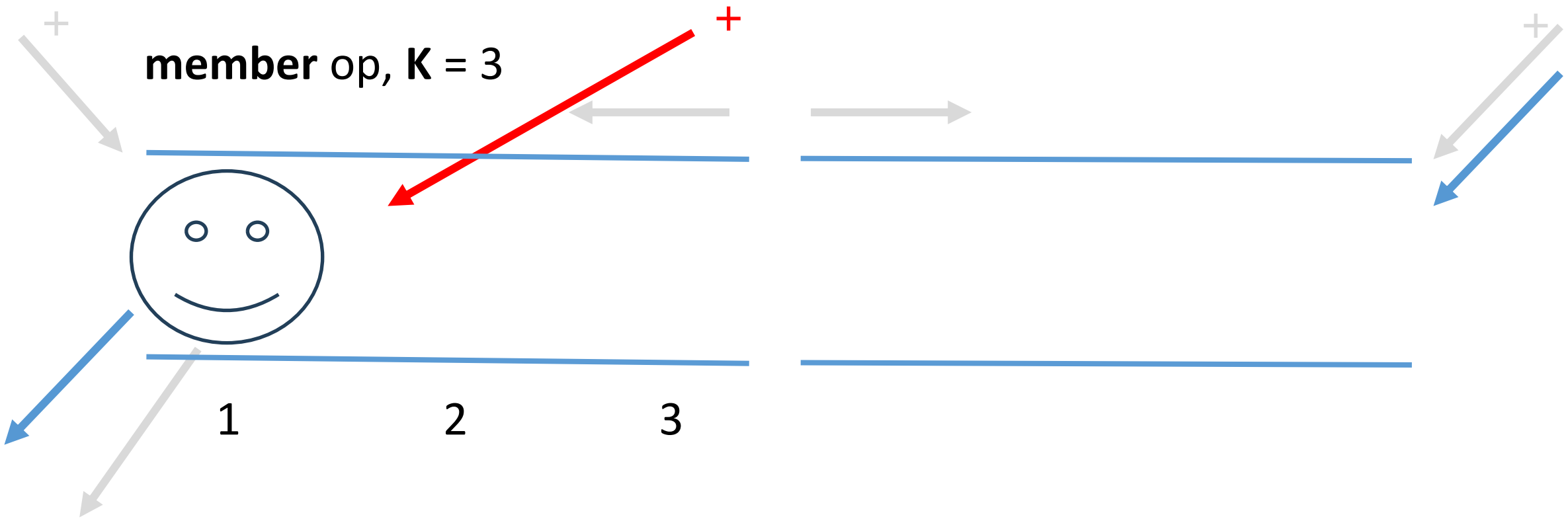
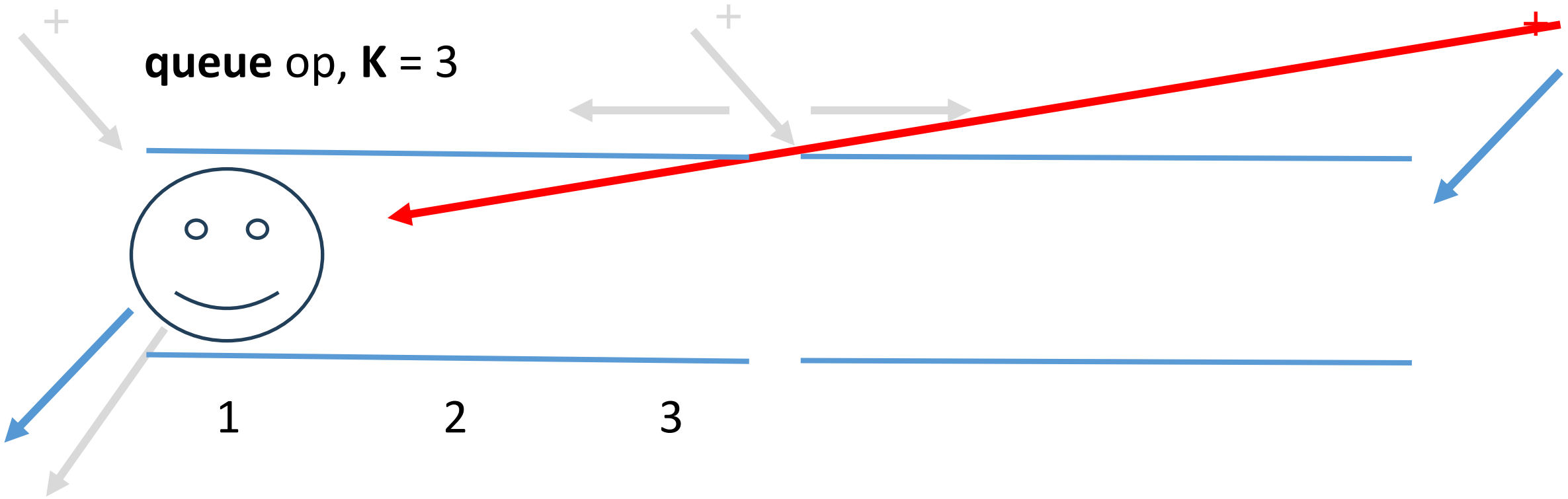
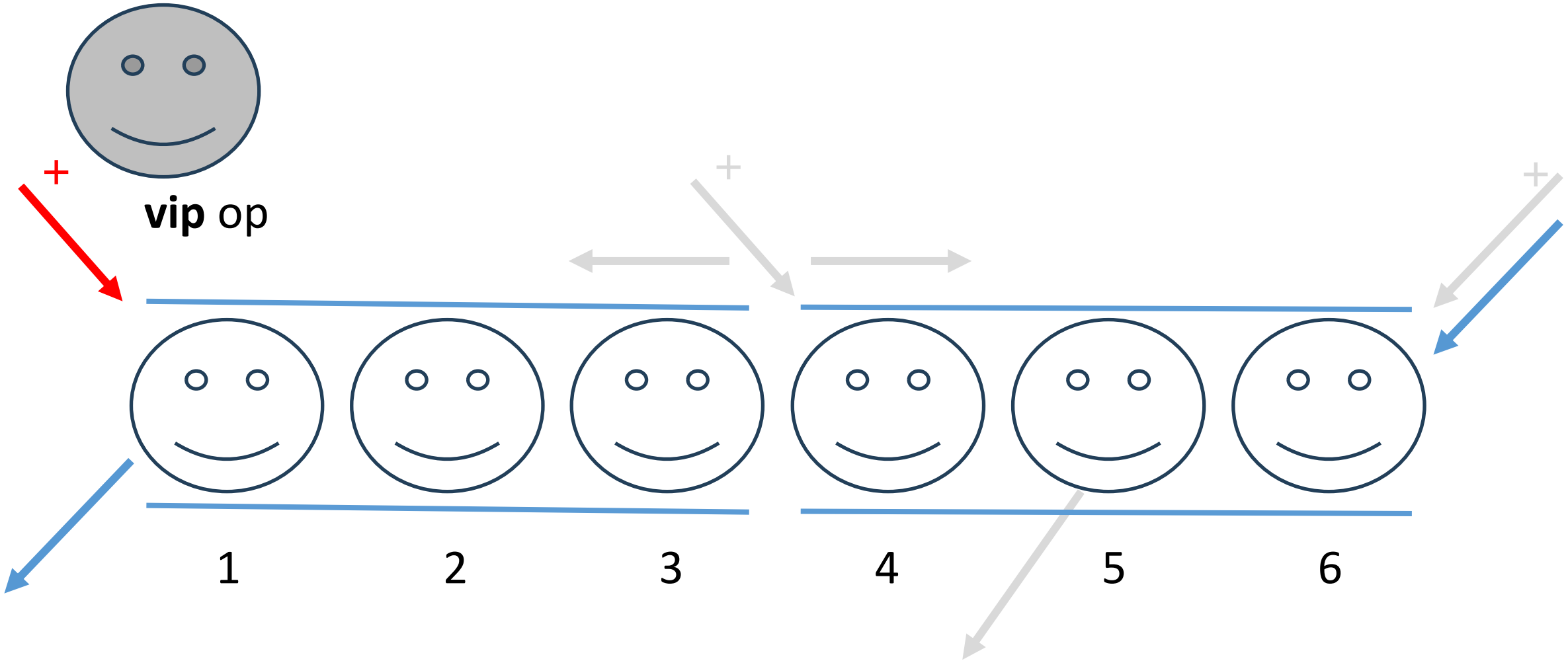


NOT always adding to front of right Deque!

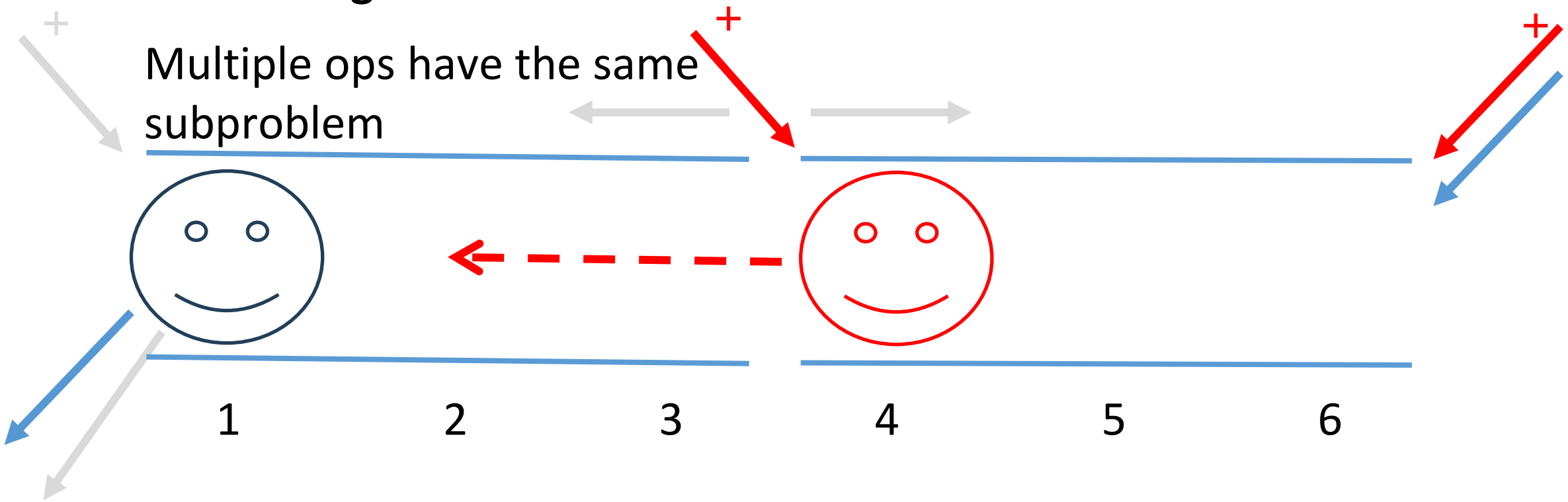


NOT always adding to back of right Deque!

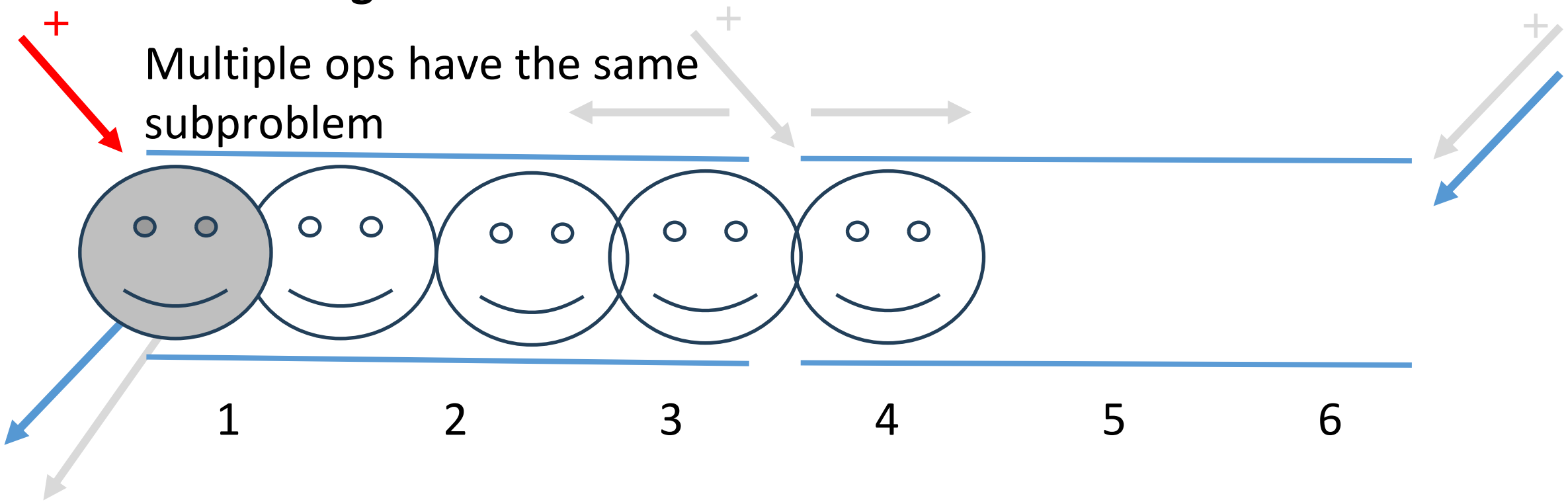


Left Deque is now **over** capacity

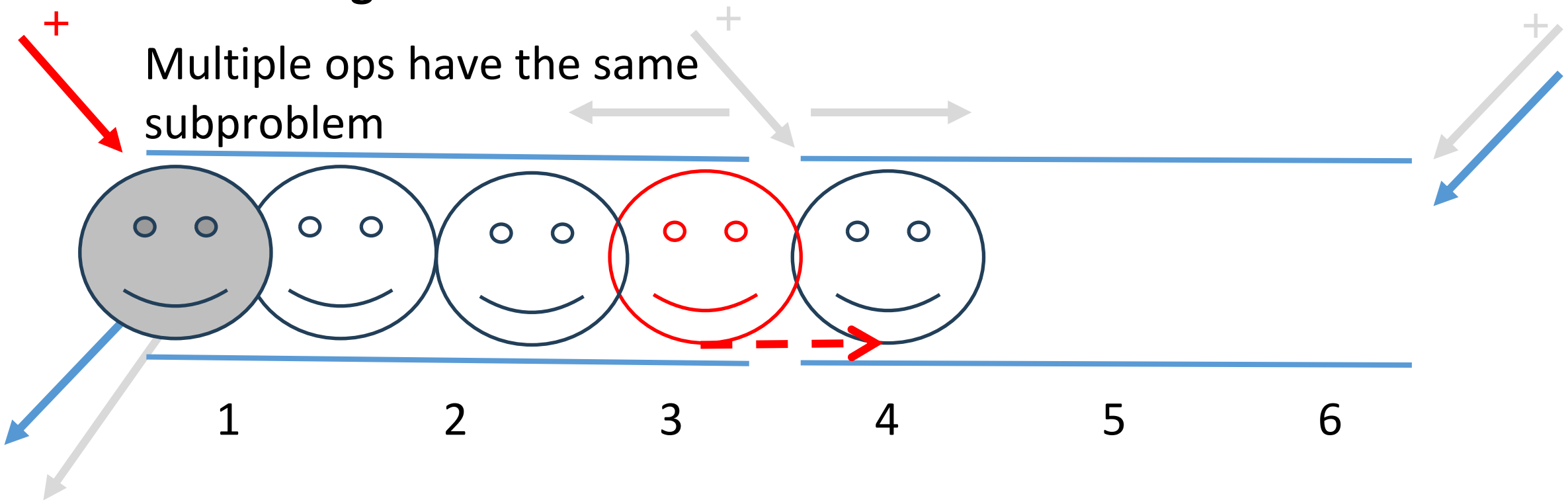
rebalancing

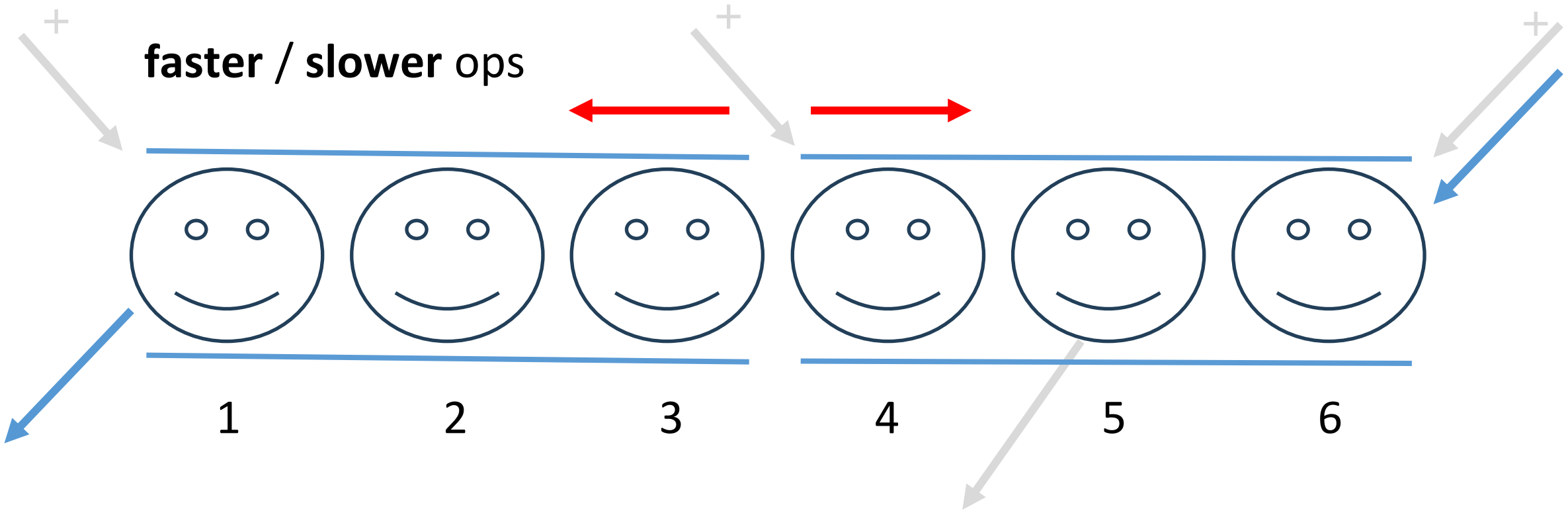


rebalancing



rebalancing





Decrease/increase **K**
then just rebalance

Lab 5 – Hashing

- Two different forms of hash tables are provided by Java
- **HashMaps** involve a key-value pair
  - The key is the object which is hashed, and then put into the HashMap depending on its resulting hash code
  - The value is a separate object that is associated with that key, and its contents are not considered when computing the hash code of the key
  - The entire key-value pair is called an entry
- **HashSets** simply involve one object, that acts as both the key and the value
  - Similar to the mathematical idea of set

Lab 5 – Hashing

- Note: there is also a Hashtable class which behaves in the same manner as a HashMap, but is generally slower than HashMap for the purposes of CS2040
  - The reason is similar to ArrayList vs Vector ie. synchronisation

Lab 5 – HashSet

Method name	Description	Time
.add(YourClass element)	Adds *element* to the HashSet	O(1) average
.clear()	Clears the HashSet	O(n)
.contains(Object o)	Checks if *o* is in the HashSet, based off the object's equals() method	O(1) average
.isEmpty()	Checks if the HashSet is empty	O(1)
.remove(Object o)	Removes *o* if it is in the HashSet, based off the object's equals() method	O(1) average
.size()	Returns the number of elements in the HashSet	O(1)

Lab 5 – HashMap

- HashMaps are the first class encountered in this module that require the use of more than one generic
- To declare a HashMap with an Integer as the key, and a String as the value:
  - `HashMap<Integer, String> map = new HashMap<Integer, String>();`
- The two generics used need not be different eg. to use an integer as the key, and another integer as the value:
  - `HashMap<Integer, Integer> map = new HashMap<Integer, Integer>();`

Lab 5 – HashMap

- HashMaps are generally useful in answering queries where the key is known, but the value is unknown
  - Eg. if we want to know which stall at a food court sells a certain food item, we could store a key-value pair of all foods, where the key is the food item's name, and the value is the stall name.
  - If we have a craving for a certain food item later, we use the food item's name to look up the HashMap, and check the value (stall name) associated with that key
- Effectively, using the key as a "reference" for the value

Lab 5 – HashMap

Method name	Description	Time
.put(YourClass key, YourClass value)	Adds *key* to the HashMap with the value *value*	O(1) average
.clear()	Clears the HashMap	O(n)
.containsKey(Object o)	Checks if key *o* is in the HashMap, based off the object's equals() method	O(1) average
.containsValue(Object o)	Checks if value *o* is in the HashMap, based off the object's equals() method	O(n)
.get(Object o)	Gets the value corresponding to the key *o*	O(1) average
.isEmpty()	Checks if the HashMap is empty	O(1)
.remove(Object o)	Removes the entry with key *o* if it is in the HashMap, based off the object's equals() method	O(1) average
.size()	Returns the number of elements in the HashMap	O(1)

Lab 5 – HashMap (cont.)

Method name	Description	Time
.entrySet()	Returns a set of all entries in the HashMap	O(1)
.keySet()	Returns a set of all keys in the HashMap	O(1)
.values()	Returns a collection of all values in the HashMap	O(1)

Unlike HashSet, it is not possible to iterate through a HashMap (eg. enhanced for-loop) directly. You will need to use the above methods to access an iterable form of the data stored within

One-Day Assignment 4 – Conformity

- Given the course combinations of students, determine how many students are taking one of the most popular combination of courses
  - There can be multiple combinations of courses which are tied for the most popular combination eg:
  - (100, 101, 102, 103, 104) – 4 students
  - (101, 102, 103, 104, 105) – 2 students
  - (102, 103, 104, 105, 106) – 4 students
  - Your answer should be 4 + 4 = 8 (the students taking the first and third combinations)
- Note that course combinations can be given in different orders, but should be considered as the same course combination
  - Eg (100, 101, 102, 103, 488) is the same combination as (103, 102, 101, 488, 100) as given in Sample Input 1