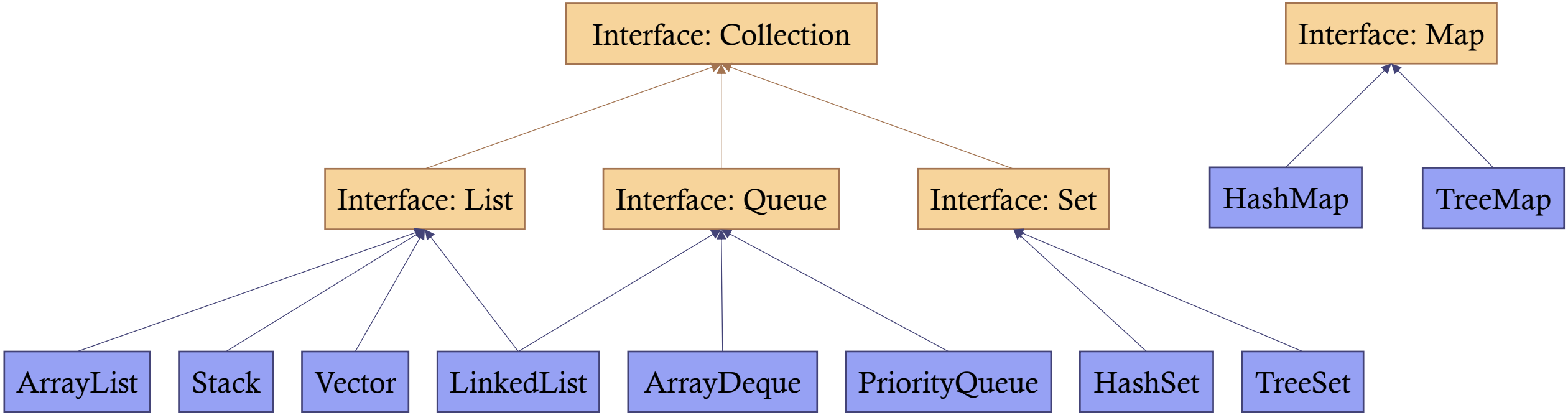
WEEK NINE

Acknowledgements: Slides created based off material provided by Dr. Michael Raymer and Dr. Travis Doom

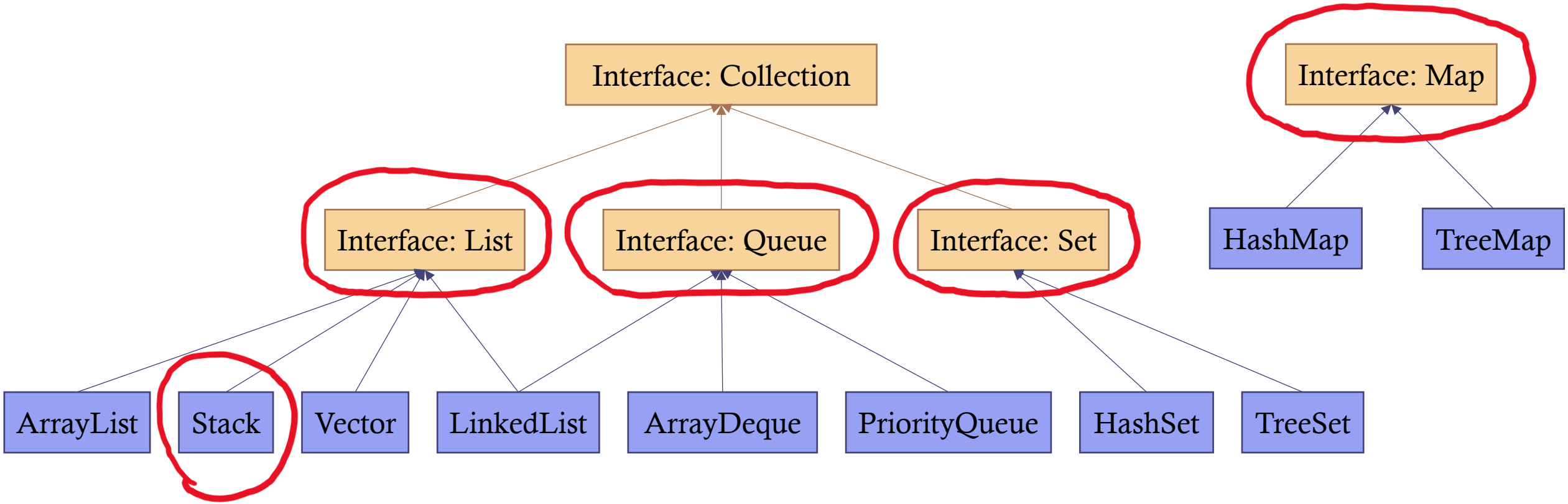
JAVA COLLECTION INTERFACE

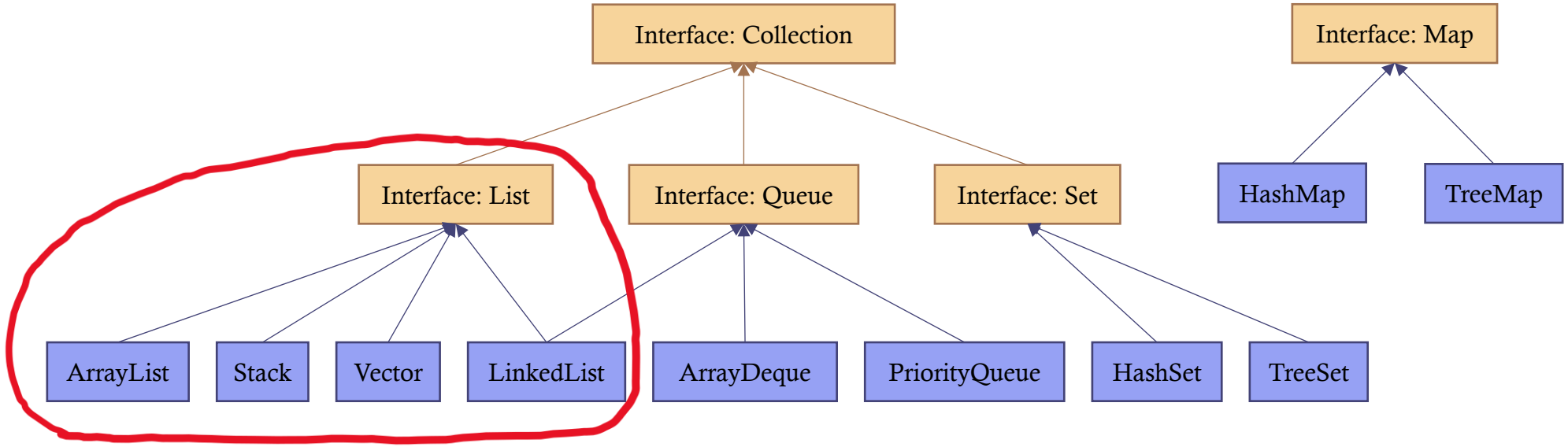


ABSTRACT DATA TYPES (ADTS)

- Abstract container for data with some loose operations
- An ADT is a general idea for data collection, details are hidden
- Describes how we want to store/interact data at a high-level
- An ADT **does not:**
  - Specify/restrict the type of data to be stored (generics)
  - Specify the implementation of operations (method bodies don't need to be specified)
  - Dictate how the data is actually stored/accessed from memory
- In Java, ADTs are often (but not always) implemented via interfaces

INTERESTING ADTS IN JAVA





LISTS

- ArrayLists
- LinkedLists

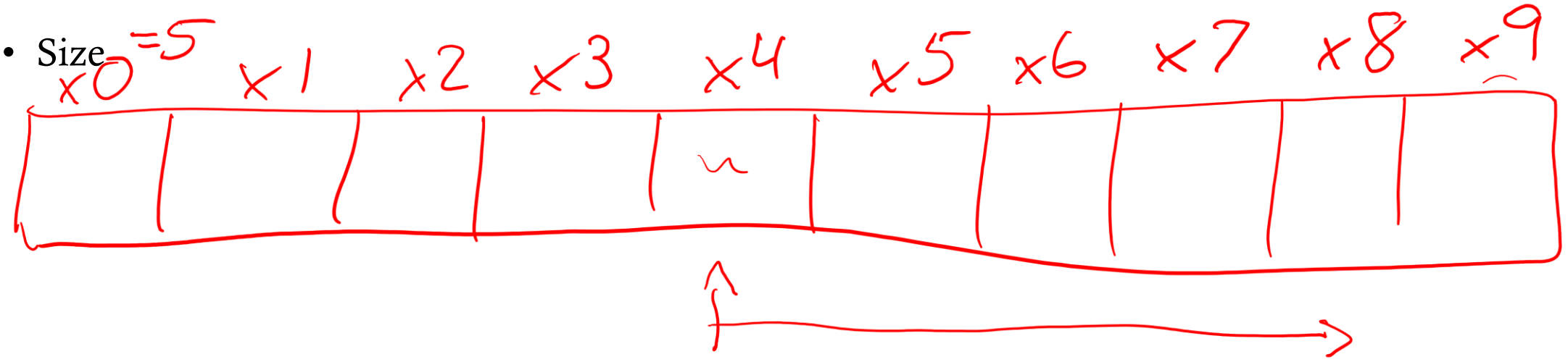
LIST INTERFACE

- An ordered, indexed collection
- Users can precisely insert/access elements via an index
- Duplicates typically allowed
- Key methods:
  - add()
  - get()
  - remove()
  - isEmpty()

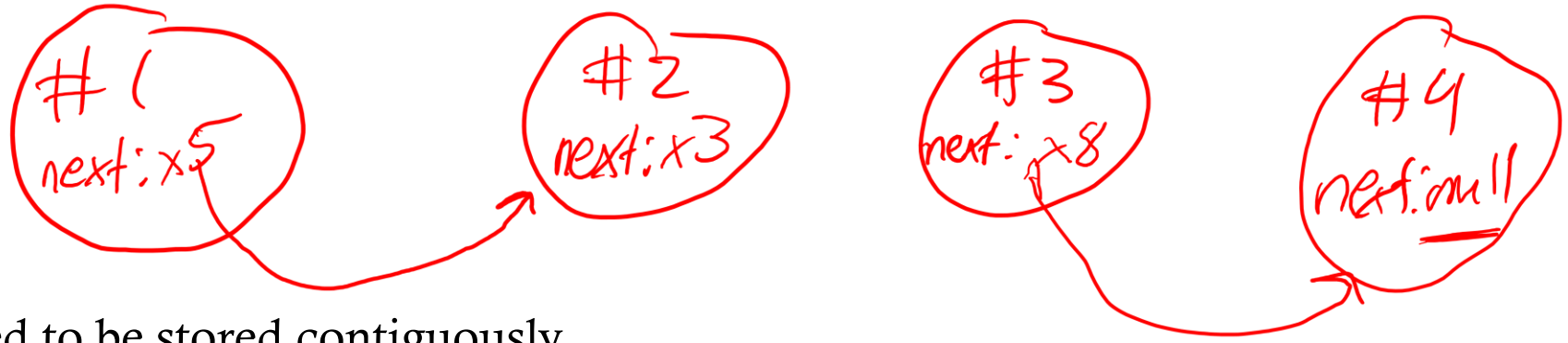
ARRAYLIST

get(2)
add(3, "hi")

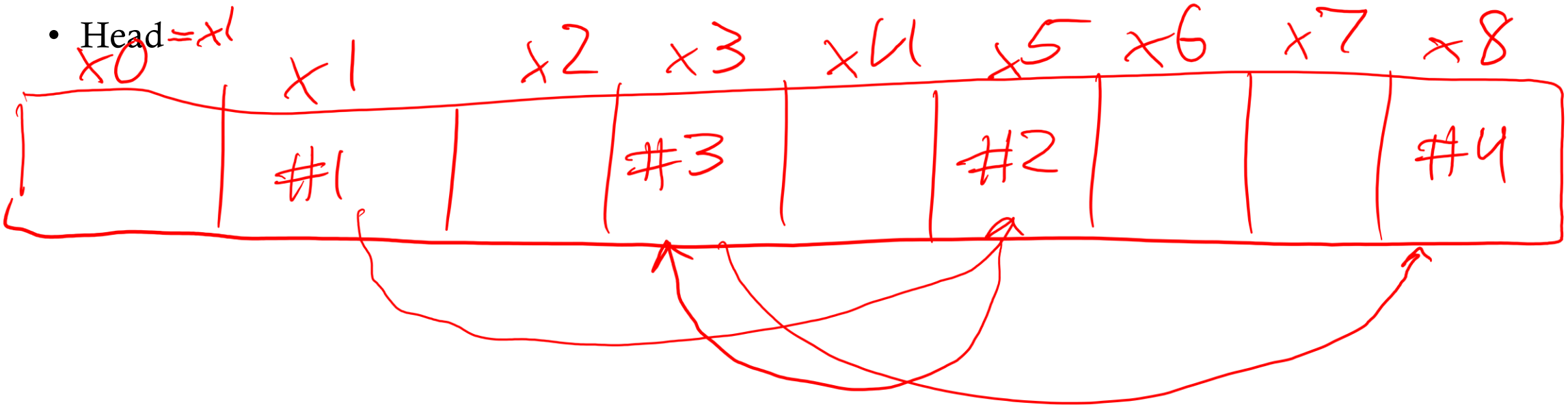
- Element references stored contiguously in memory
- Start = x4
- Size = 5

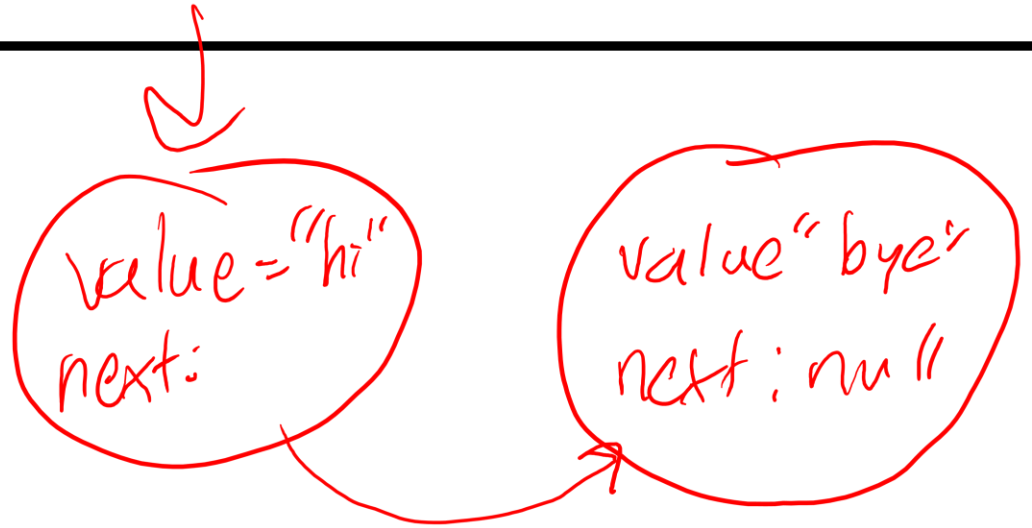


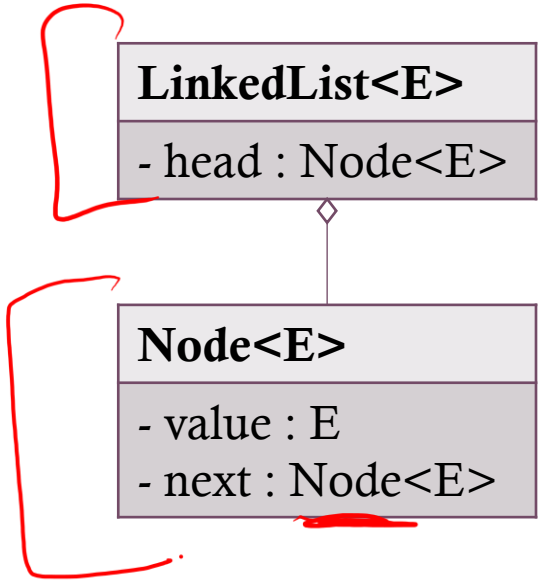
LINKEDLIST



- Element references don't need to be stored contiguously
- Each element holds a *link* or reference to the next item in the list
- Head = x1







LINKEDLIST

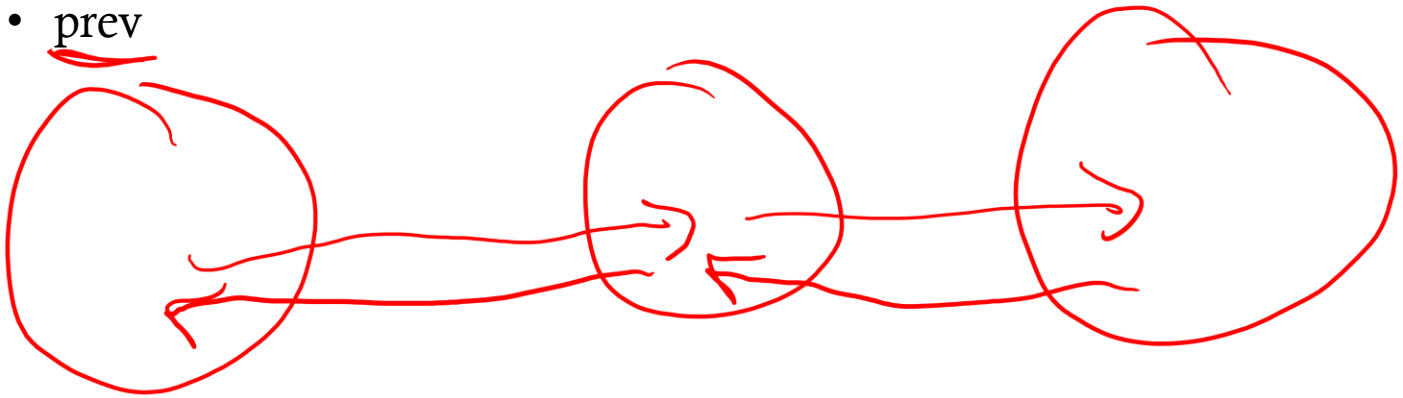
How do we implement our own LinkedList?

ACTIVITY

- Write one of the following methods for a LinkedList class
  - toString(): returns the contents of the list in String format
  - get(): takes in an index and returns the value of the node at that position
  - replace(): takes in an index and new value; replaces the value at the index position with the new value
- Make sure to consider if your method relies on any methods in the Node class

DOUBLELINKEDLIST

- Each node now has two pointers:
  - next
  - prev



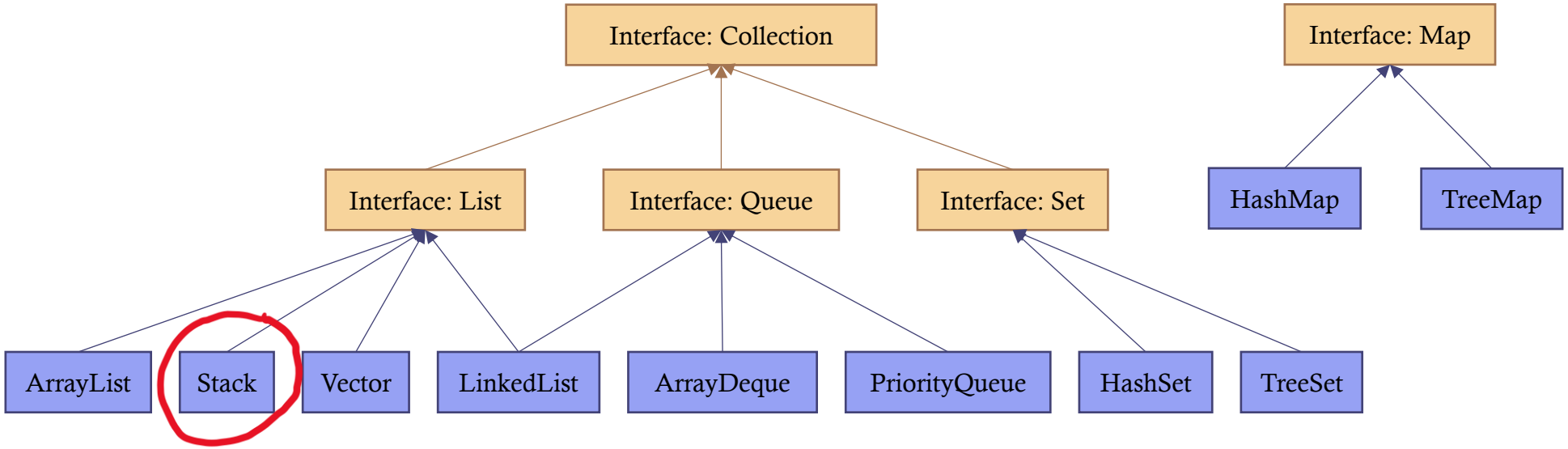
PROS AND CONS OF LIST IMPLEMENTATIONS

ArrayList

- Slow insert/remove
- **Efficient data access/storage**
- **Uses less memory**
- Less efficient memory usage

LinkedList

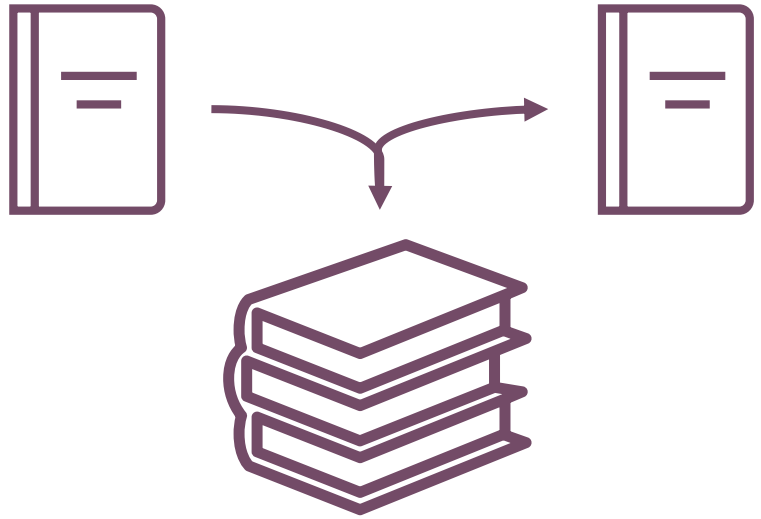
- **Fast insert/remove**
- Slow data access/storage
- Uses more memory
- **More efficient memory usage**


Interface: Collection
Interface: Map
Interface: List
Interface: Queue
Interface: Set
HashMap
TreeMap
ArrayList
Stack
Vector
LinkedList
ArrayDeque
PriorityQueue
HashSet
TreeSet

STACKS

STACK ADT

- Follows the Last In First Out philosophy (LIFO)
- Restricts modification to the “top” of the collection
- Could imagine as a stack of books
- Key methods:
  - push(): add
  - pop(): remove
  - peek(): view but don’t remove
  - contains()
  - clear()
  - isEmpty()



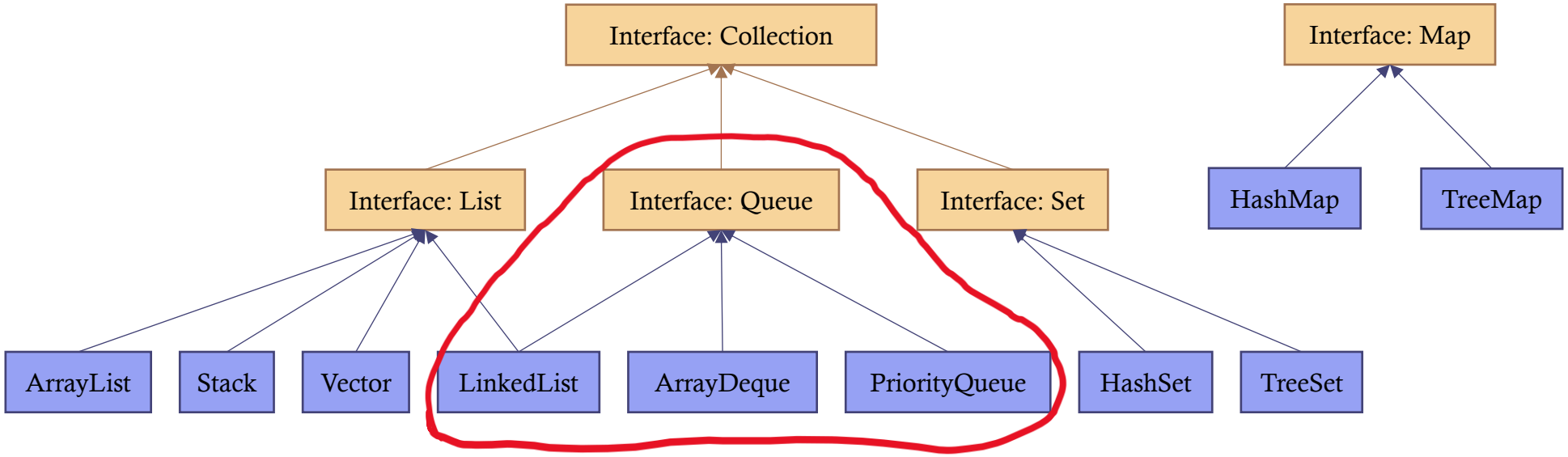
STACK USES

- `Stack<Integer> s = new Stack<>();`

- Reversing a set of commands (undo/redo)
- Returning to start (reversing a set of directions)
- Reversing a list
- Deck of cards (draw/discard piles)

STACK ACTIVITY

- What are the contents of the stack after the following methods are run?
  - push(5)
  - push(3)
  - push(8)
  - pop()
  - peek()
  - pop()
  - push(1)
  - push(4)
  - pop()



QUEUES

- LinkedList
- ArrayDeque
- PriorityQueue

QUEUE ADT

- Follows the First In First Out philosophy (FIFO)
- Only adds to the front and removes from the back
- Restricts internal modification
- Could imagine as a line at a checkout
- Key methods:
  - offer(): add
  - poll(): remove
  - peek(): view but don't remove
  - contains()
  - clear()
  - isEmpty()

QUEUE USES

- `Queue<Integer> q = new ArrayDeque<>();`
- `Queue<Integer> q = new LinkedList<>();`

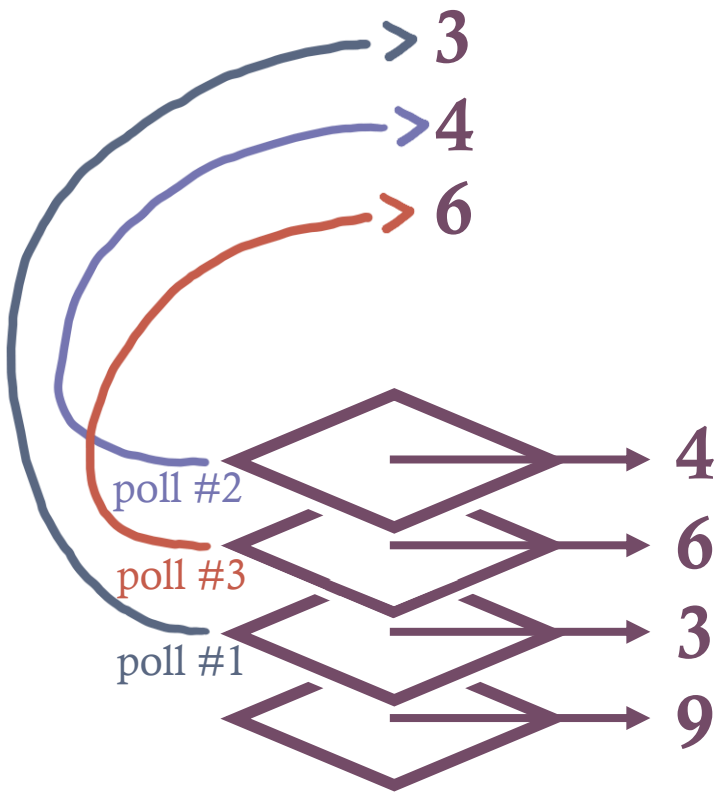
- Sequence of customers to handle one by one
- Process tasks in the order they are received
- Schedule of items

QUEUE ACTIVITY

- What are the contents of the stack after the following methods are run?
  - offer(4)
  - offer(7)
  - offer(1)
  - poll()
  - poll()
  - offer(3)
  - offer(1)
  - peek()
  - offer(3)
  - poll()

PRIORITY QUEUES

- Polls items based on their "priority"
  - Essentially, we define the order that items are removed
  - Higher priority means the item will come first when sorted
  - **NOTE:** priority queues are not internally sorted
  - The only guarantee is that the next item that is polled is the next item according to the set priority
- Default ordering
  - Numbers sorted lowest first
  - Strings sorted alphabetically
  - Other types sorted via compareTo() or a comparator



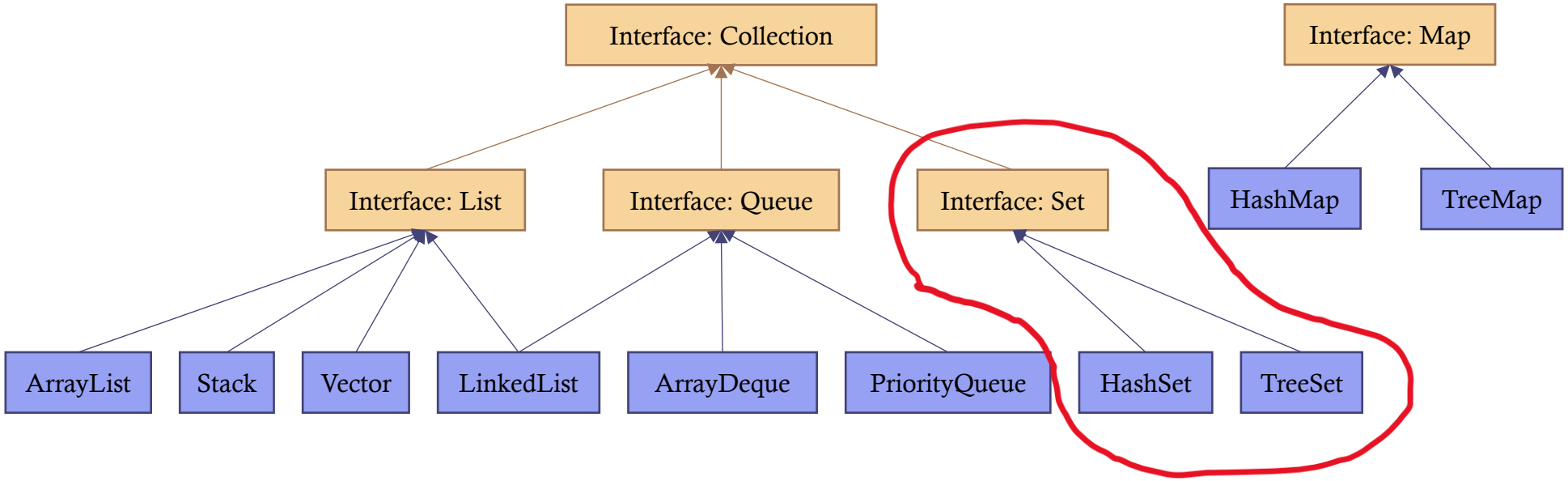
PRIORITY QUEUE USES

- `PriorityQueue<Integer> q = new PriorityQueue<>();`

- Customer assistance order (call-ahead/scheduled customers skip the line)
- Grabbing word bank words in alphabetical order
- Banking system set to handle larger transactions first

ACTIVITY

- Create a system to manage tasks
- You will need to create a very simple Task class
  - Field for a description of the Task
  - Field for the Task priority level
  - Method to allow sorting via priority
- Main class should have the following functionality
  - Ability to grab the highest priority Task currently in the list
  - Ability to “complete” Tasks and move them to a structure for completed items
  - Ability to retrieve the most recently completed Task



SETS

- HashSet
- TreeSet

SET INTERFACE

- Modeled after mathematical sets
- No order
- No duplicates allowed
- Primary purpose is to determine whether an element is in a specific set
- Key methods:
  - add()
  - remove()
  - isEmpty()
  - size()

SET USES

- Powerball
- Check for duplicate letters in a word
- Roster of UIDs
- Color palette

HASHSET

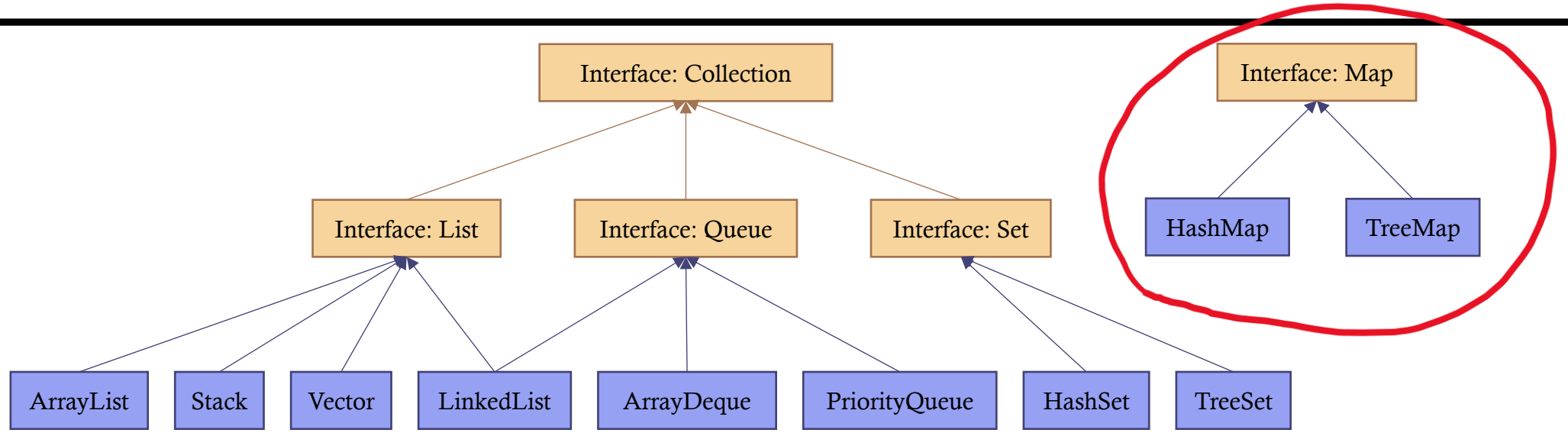
- `Set<Integer> s1 = new HashSet<>();`

- Based on a high-performance data structure called a hash table
  - Hash is calculated for the element to be stored using a key
  - *Hash % value* is performed to determine which "bucket" to place the element in
  - Behind the scenes, structure is optimized to have few empty buckets and to minimize number of elements per bucket
  - Since key is known, hash and corresponding bucket can easily be determined when searching for an element
  - Then only that bucket needs to be searched

TREESET

- `Set<Integer> s2 = new TreeSet<>();`

- Based on a tree data structure
  - Elements are naturally ordered
  - Elements are linked to each other in a tree format
  - For this tree implementation, each element may only have two child nodes



MAPS

- HashMap
- TreeMap

MAP INTERFACE

- Maps keys and values
- Essentially works like a look-up table
- Keys must be unique and only connect to one value
- Values may be duplicated
- Key methods:
  - put()
  - get()
  - remove()
  - keySet()
  - values()

MAP USES

- Read a text file and count the number of uses of each word
- Dictionary: pairing words with their definitions
- Student name and number of credit hours
- Customer and total money spent

HASHMAP & TREEMAP

- `Map<Integer, String> checkOuts1 = new HashMap<>();`
- `Map<Integer, String> checkOuts2 = new TreeMap<>();`

- Underlying implementations are similar to Sets
  - Hash table
  - Naturally ordered tree

ITERABLE & ITERATOR INTERFACES