MAHARISHI UNIVERSITY of MANAGEMENT

Engaging the Managing Intelligence of Nature

Computer Science Department

CS390 Foundamental Programming Practices (FPP)

Professor Paul Corazza

Lecture 9:
Stacks and Queues

Wholeness of the Lesson

Stacks and Queues are, essentially, a special kind of list with a highly restricted interface that permits rapid insertion and rapid access to elements, according to a "last in, first out" (Stacks) or "first in, first out" (Queues) scheme. These data structures express the Maharishi Vedic Science principle that creation emerges in the collapse of infinity to a point.

The STACK ADT

- **Definition:** A STACK is a LIST in which insertions and deletions can occur relative to just one designated position (called the *top of the stack*).
- **Example of a Stack:**

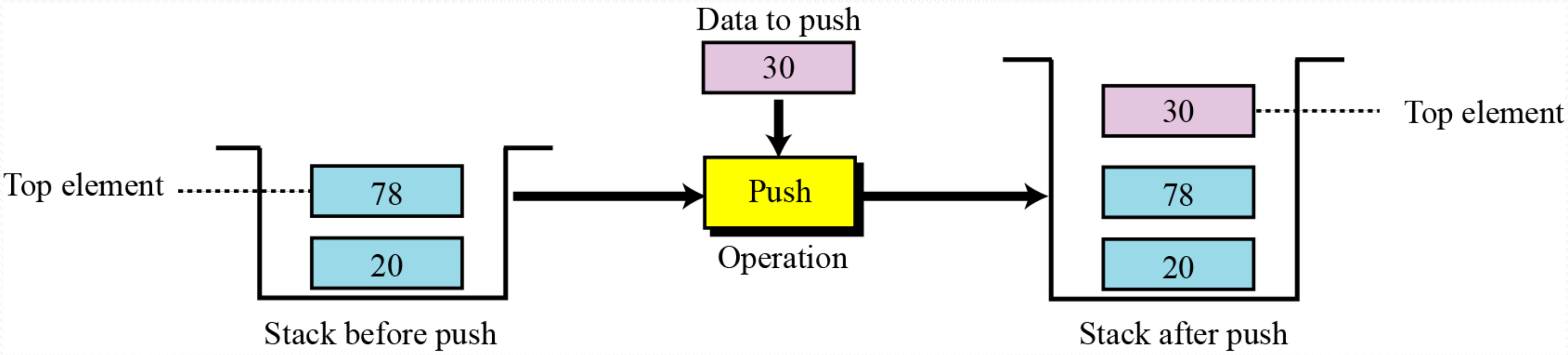
The Stack ADT

- **Operations:**

pop	remove top of the stack and return this object)
push	insert object as new top of stack
peek	view object at top of the stack without removing it

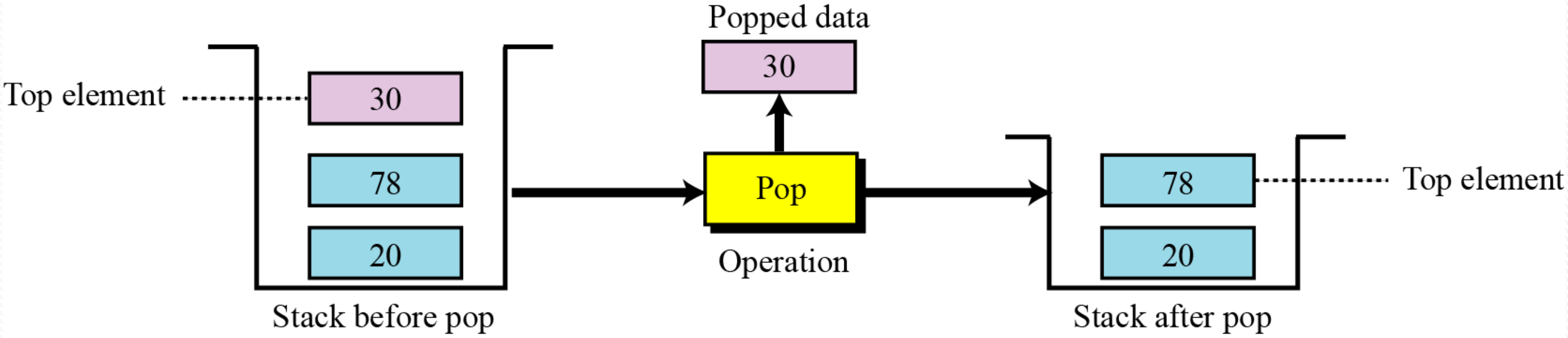
The Stack ADT

- **push operation:**



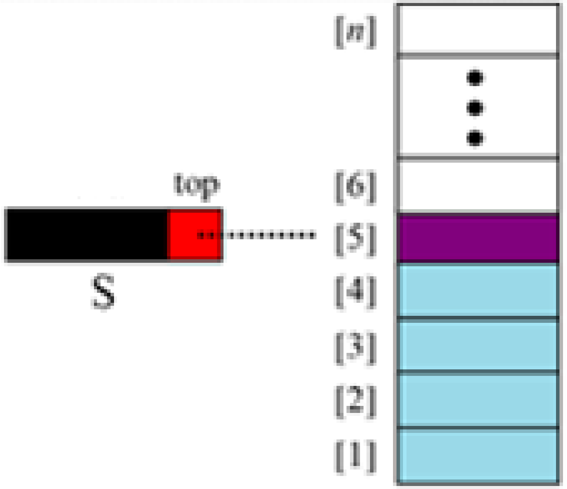
The STACK ADT

- **pop operation:**



Implementation of STACK Using an Array

- **Usual strategy**: Designate the rightmost array element to be the top of the stack.
- **Detail**: To avoid traversing the array in search of the current top of the Stack, maintain a pointer to the rightmost element.
- **Advantage**:
  - Avoids the usual cost of copying array elements that is required in insertion and deletion of arbitrary array elements
- **Disadvantage**:
  - If usage requires many more pushes than pops, the underlying array will have to be resized often, and this is costly

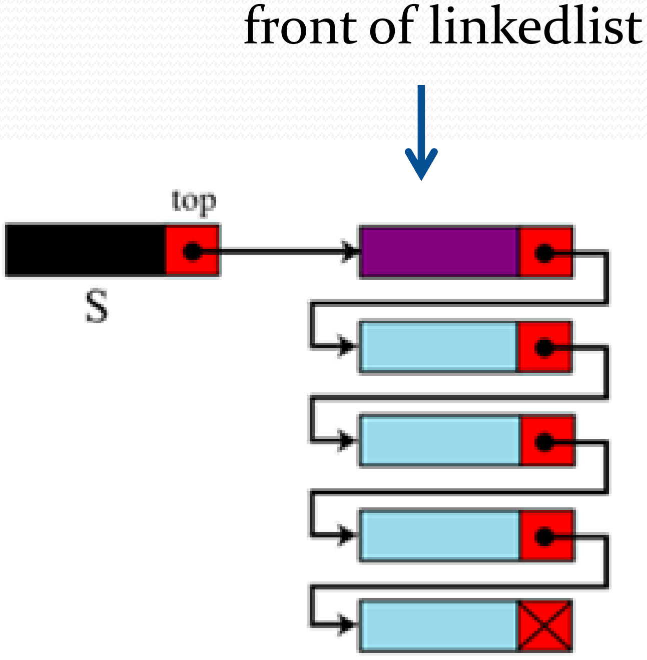


Implementation of STACK Using a Linked List

- The usual `addFirst` operation in a Java `LinkedList` adds the new element to the front of the list. Therefore, an object `S` can be pushed onto a Java LinkedList `ll` with the call
  `ll.addFirst(S)`

- The peek operation is equivalent to *find0th* (in a Java LinkedList, it is the call `get(0)`).

- The pop operation is equivalent to *find0th* followed by a call to `remove(0)`.



Java's Implementation of Stack

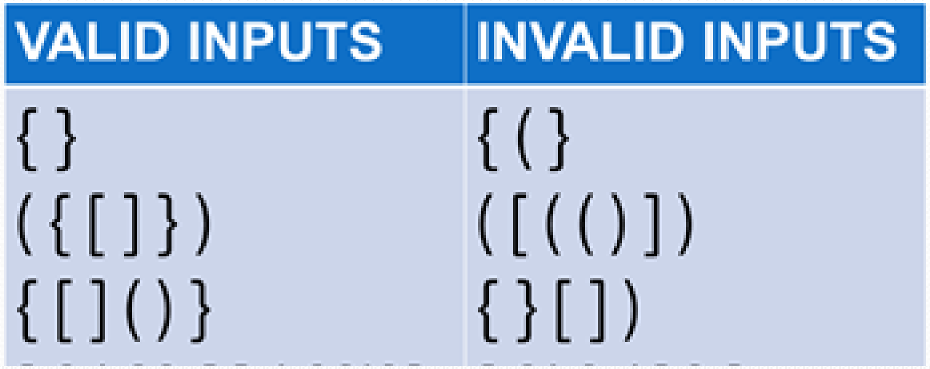
- The Java distribution comes with a `Stack` class, which is a subclass of `Vector`.

- `Vector` is an array-based implementation of `List`. Therefore, for implementations that require many more pushes than pops, a stack based on a Linked List should be used instead.

- Exercise: Implement your own class `MyStringStack` that uses `MyStringLinkedList`.

Application of Stacks: Symbol Balancing

- A Stack can be used to verify whether all occurrences of symbol pairs (for symbol pairs like (), [], {}) are properly matched and occur in the correct order.
- For example:



VALID INPUTS	INVALID INPUTS
{ }	{ (}
({ [ ] })	([(( )])
{ [ ] ( ) }	{ } [ ])

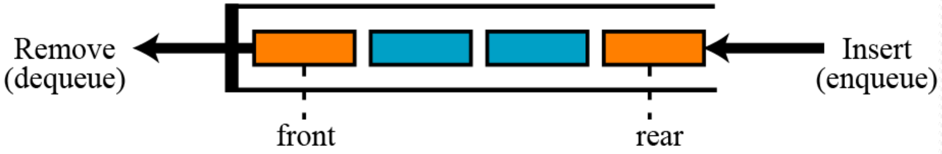
Application of Stacks: Symbol Balancing

- The following procedure can be used:
  - Begin with an empty Stack
  - Scan the text (will ignore all non-bracketing symbols)
  - When an open symbol (like '(' or '[') is read, push it
  - When a closed symbol (like ')' or ']') is read, pop the Stack –
    1. if the stack is empty (so it can't be popped) return false.
    2. if the popped symbol doesn't match the symbol just read, return false.
  - After scanning is complete, if the Stack is not empty, return false.
- See Symbol Balancer demo

The Queue ADT

- **Definition.** Like a Stack, a Queue is a specialized List in which insertions may occur only at a designated position (the *back*) and deletions may occur only at a designated position (the *front*).

A queue of people



A computer queue

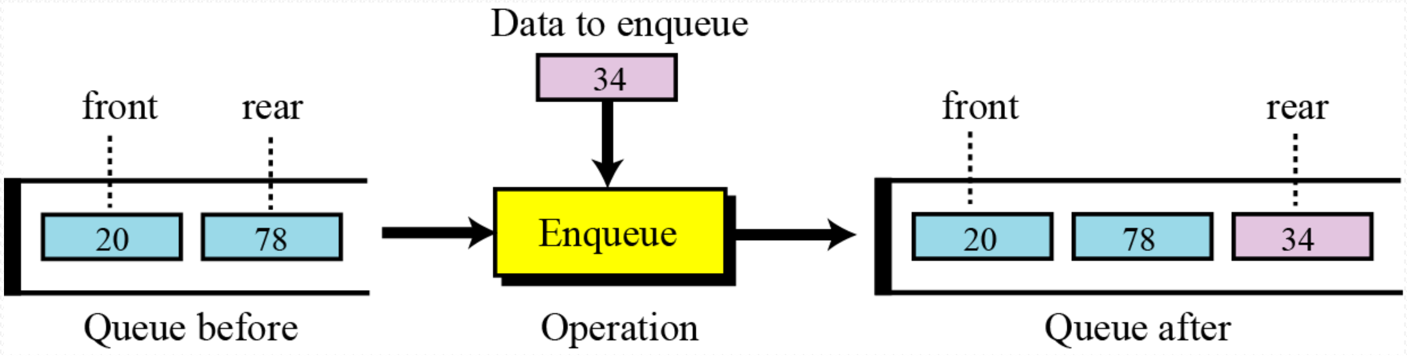
The Queue ADT

- **Operations**:

dequeue	remove the element at the front (usually also returns this object)
enqueue	insert object at the back
peek	view object at front of queue without removing it

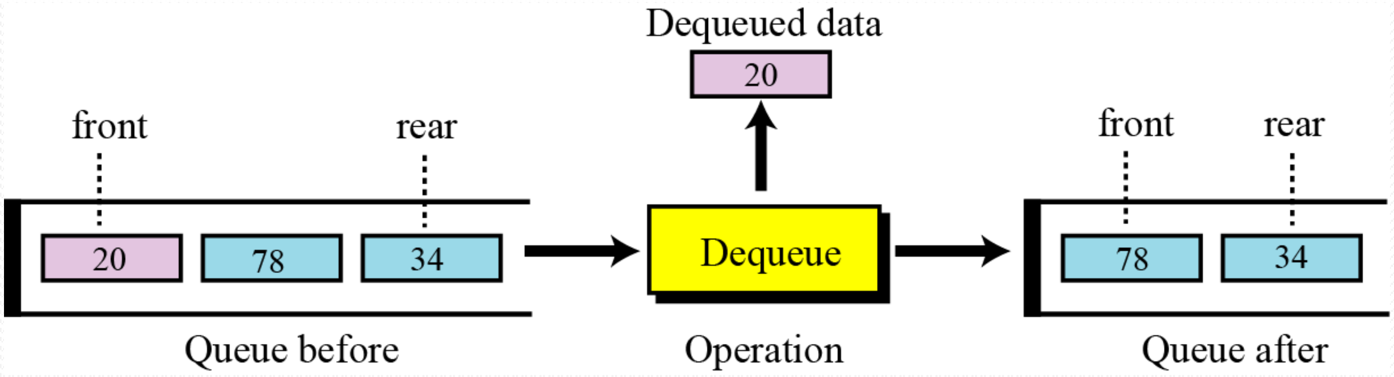
The Queue ADT

- **enqueue operation:**

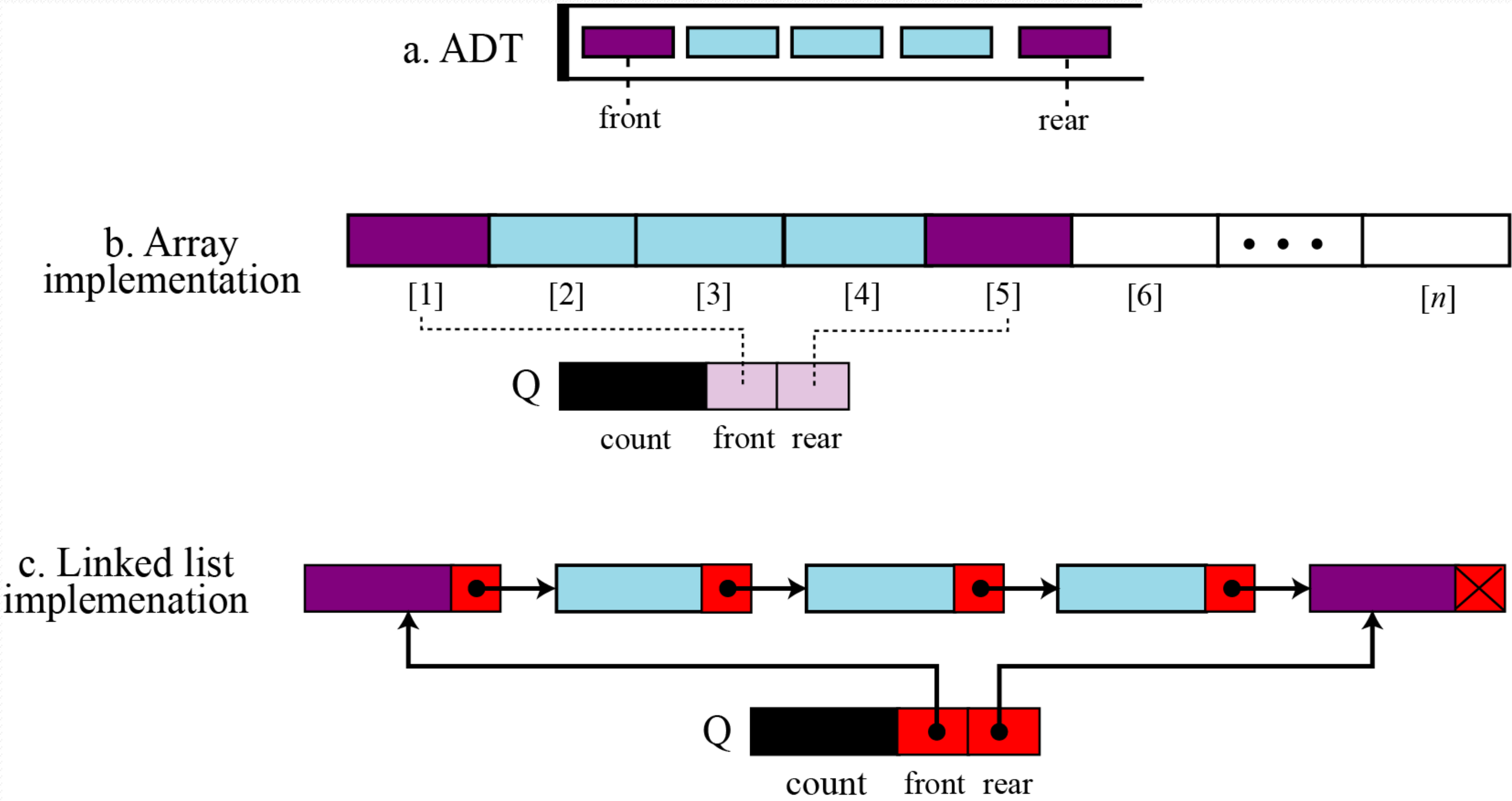


The QUEUE ADT

- **dequeue operation**:



Implementations of QUEUES

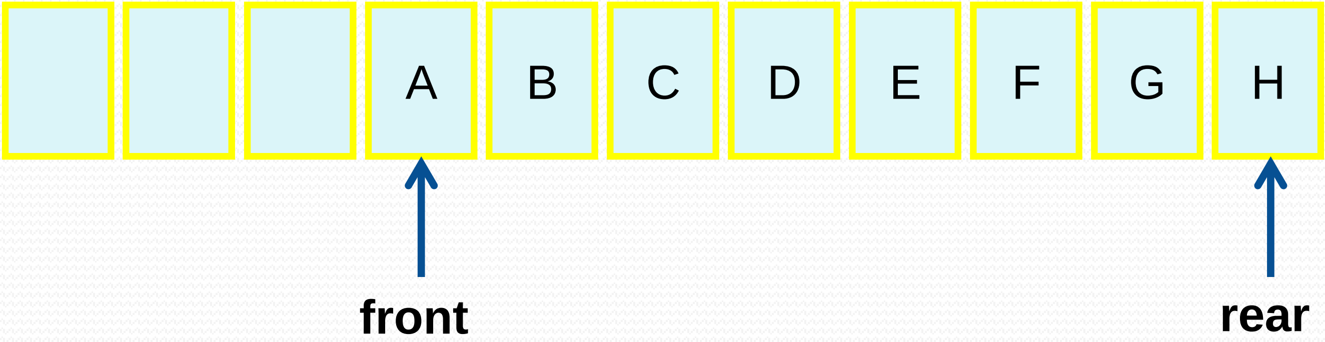


Implementations of QUEUEs

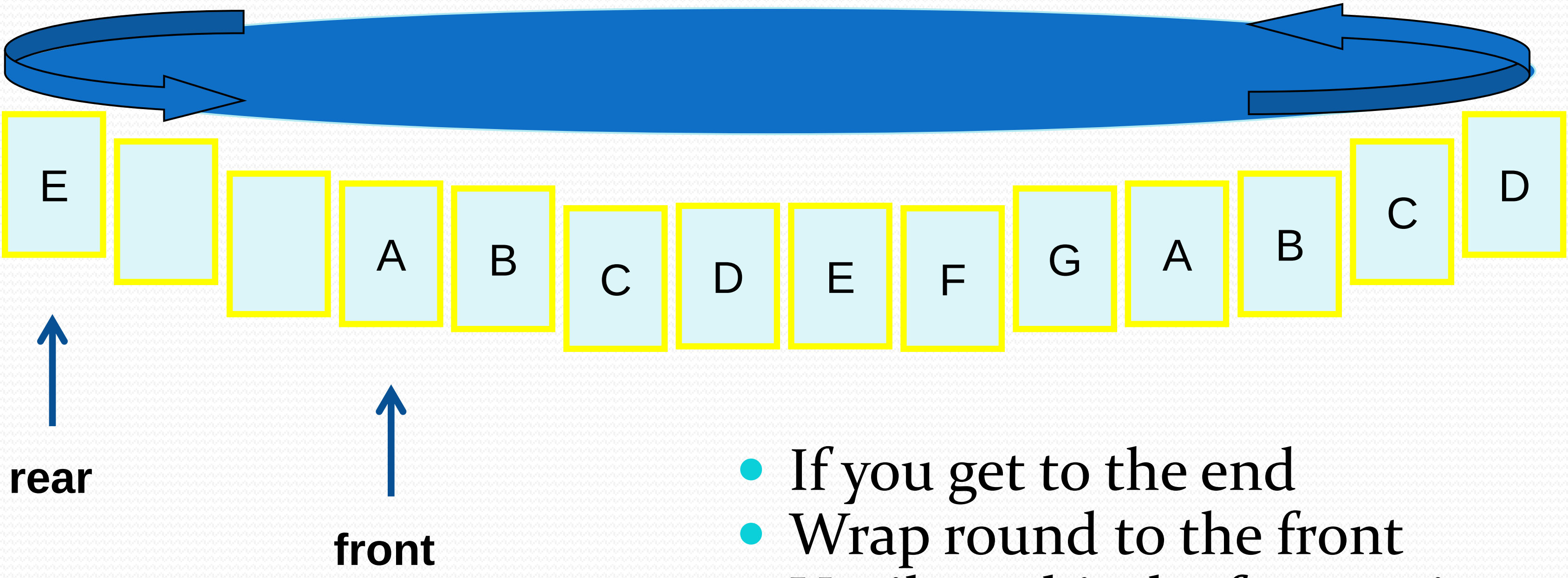
- **Using a Linked List**
  - The enqueue operation is equivalent to adding the element to the last of a LinkedList.
  - The dequeue operation is equivalent to removing the element at the front of a LinkedList.

Implementations of QUEUES

- **Using an Array**
  - Need to maintain pointers to front and back elements
  - Repeated enqueuing will fill the right half of the array prematurely—solution is to wrap around to the front.



Circular Queue



- If you get to the end
- Wrap round to the front
- Until you hit the front pointer
- It's not really a circle!

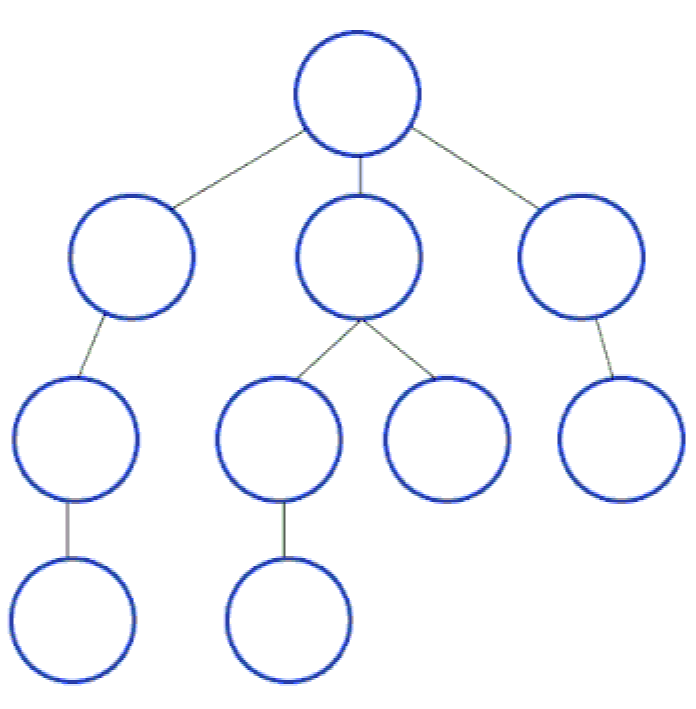
- **Java's Implementation**
  - In j2se5.0, an interface `Queue<E>` (implemented by `LinkedList<E>`) is provided, with these declared operations:
    - `E peek()` – returns but does not remove the front of the queue
    - `void add(E obj)` – same as enqueue
    - `E remove()` – returns and removes the front of the queue (same as dequeue)

Application of Queues: The Queue Game and Breadth First Search

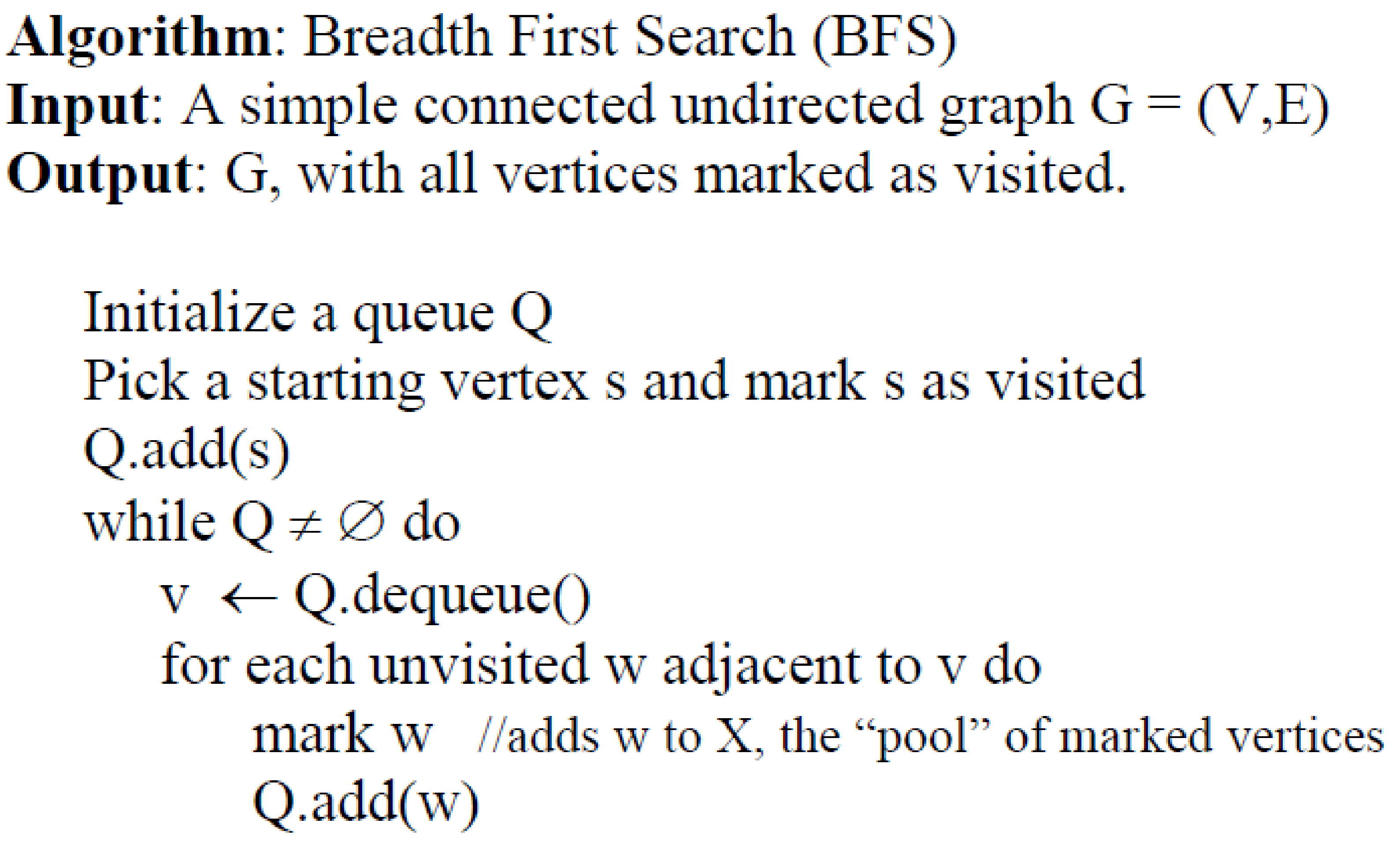
Breadth First Search is a strategy for visiting every vertex in a graph.

BFS Animated GIF

Idea. Pick a starting vertex. Visit every adjacent vertex. Then take each of those vertices in turn and visit every one of its adjacent vertices. And so forth. Use a Queue to keep track of recently visited vertices.



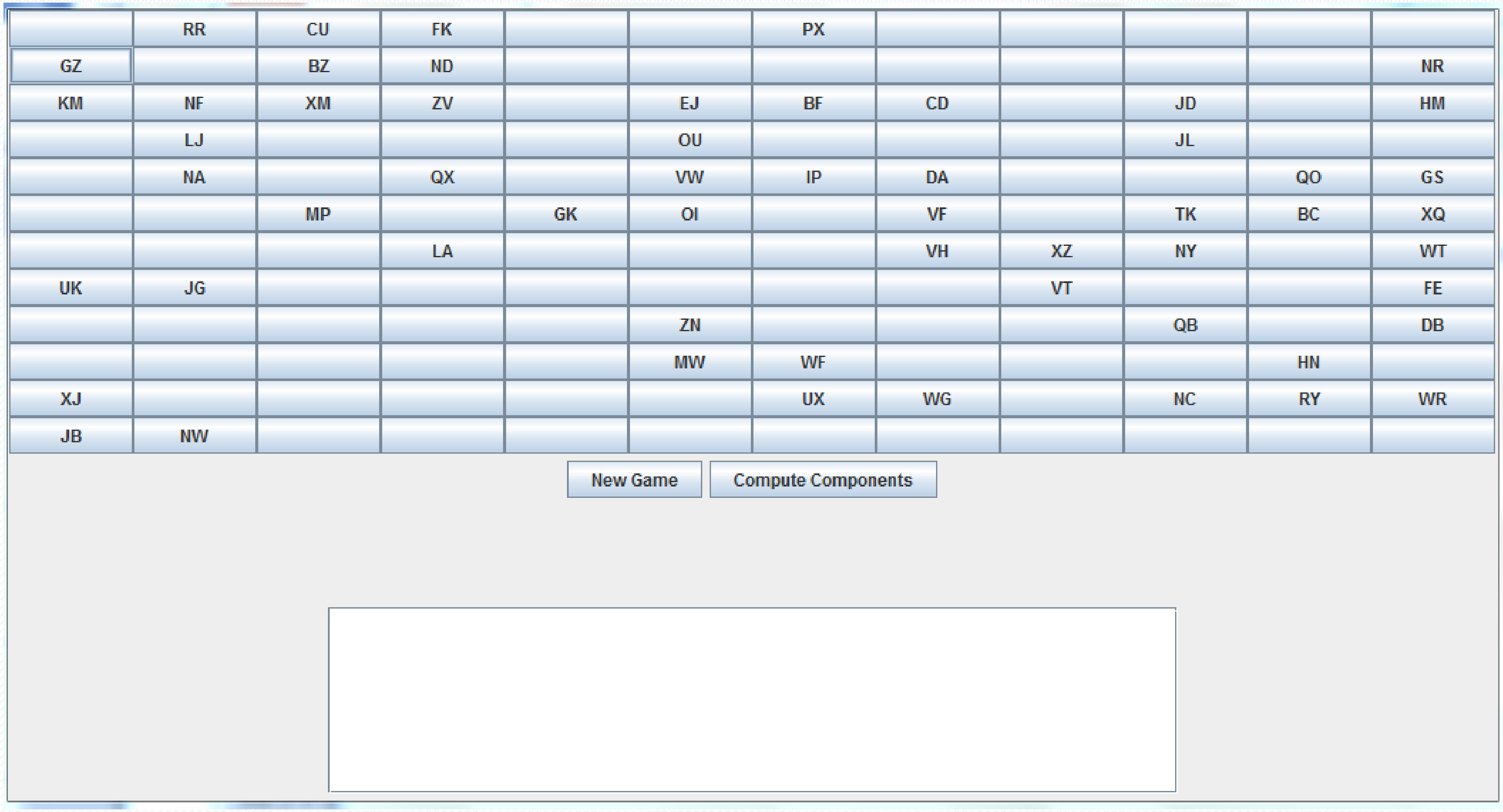
Breadth First Search Algorithm



Algorithm: Breadth First Search (BFS)
Input: A simple connected undirected graph G = (V,E)
Output: G, with all vertices marked as visited.

```
Initialize a queue Q
Pick a starting vertex s and mark s as visited
Q.add(s)
while Q ≠ ∅ do
    v ← Q.dequeue()
    for each unvisited w adjacent to v do
        mark w   //adds w to X, the "pool" of marked vertices
        Q.add(w)
```

The Queue Game



	RR	CU	FK			PX					
GZ		BZ	ND								NR
KM	NF	XM	ZV		EJ	BF	CD		JD		HM
	LJ				OU				JL		
	NA		QX		VW	IP	DA			QO	GS
		MP		GK	OI		VF		TK	BC	XQ
			LA				VH	XZ	NY		WT
UK	JG							VT			FE
					ZN				QB		DB
					MW	WF				HN	
XJ						UX	WG		NC	RY	WR
JB	NW										

Main Point

The Stack ADT is a special ADT that supports insertion of an element at “the top” and the removal of the top element, by way of operations *push* and *pop*, respectively. Similarly, the Queue ADT is a special ADT that supports insertion of an element at “the rear” (called *enqueuing*) and removal of an element from the “front” (called *dequeuing*). Both ADT’s, when implemented properly, are extremely efficient. Sun provides a Stack class and a Queue interface in its Collections API.

Stacks and Queues make use of the Maharishi Vedic Science principle that the dynamism of creation arises in the concentration of dynamic intelligence to a point value ("collapse of infinity to a point"); stacks and queues achieve their high level of efficiency by concentrating on a single point of input (top of stack or rear of queue) and a single point of output (top of stack or front of queue).

Connecting the Parts of Knowledge With the Wholeness of Knowledge

Collapse of infinity to a point embodied in Stacks and Queues

1. Lists may be used as an all-purpose collection class. Nearly any need for storing collections of objects can be met by using some kind of list, though in some cases, other choices of data structures could improve performance. Lists have a more "unbounded" range of applicability.
2. Stacks and Queues are extremely specialized data structures, designed to accomplish (primarily) two operations with optimum efficiency. These data structures have a restricted range of applicability that is like a "point".

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3. **Transcendental Consciousness:** Transcendental Consciousness is the unbounded value of awareness.
4. **Wholeness moving within itself**: In Unity Consciousness, creation is seen as the teraction of unboundedness and point value: the unbounded collapses to its point value; point value expands to infinity; all within the wholeness of awareness.