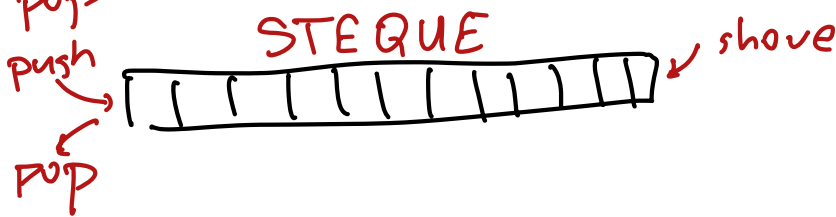
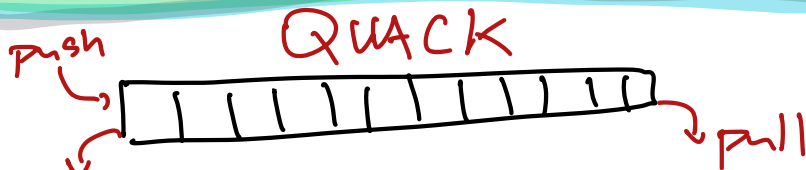
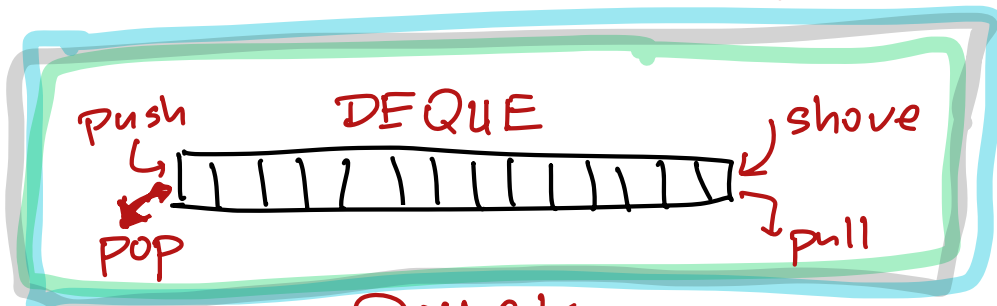
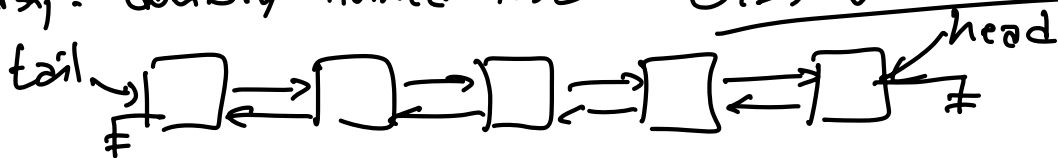


"Ended" Sequence data types



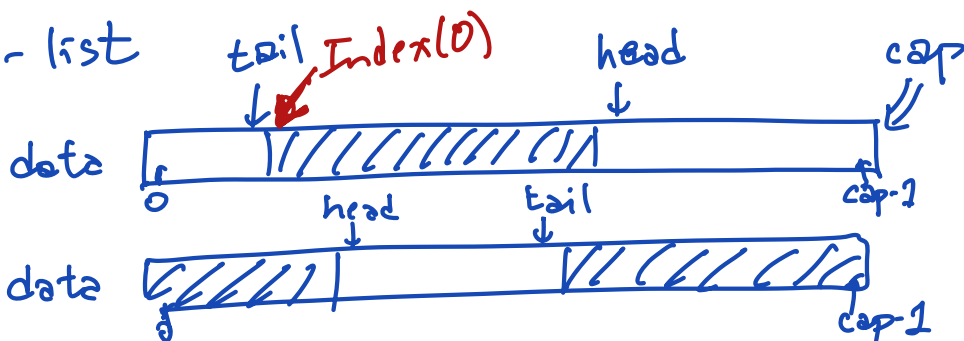
Easy: doubly-linked list $O(1)$ worst case each



Index(k): return kth item (from back) in sequence.

$$\Theta(\min\{k, n-k\}) = \Theta(n) \text{ worst case.}$$

Array-list



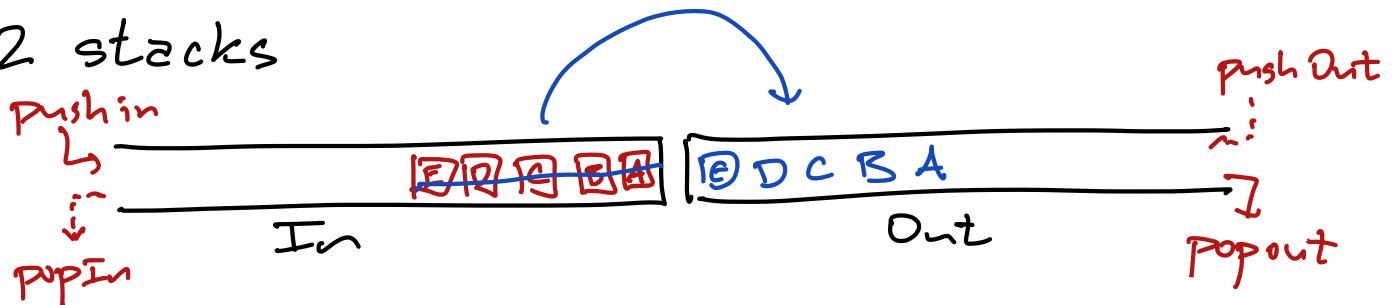
Index(k): return data[tail + k + 1 mod cap]

% is broken!

If data is full double it
data is 1/4 full halve it } $O(1)$ am. time

Black-box stacks \rightarrow queue?

2 stacks



QPush(x):

PushIn(x)

$O(1)$ time

QPull():

if Out is empty

while In is not empty
PushOut(PullIn())

return PullOut()

$O(n)$ time
worst case

Claim: For any seq. of Queue ops, amortized each op takes $O(1)$ stack ops.

① Change stack ops in transfer to earlier

QPushes

QPush \rightarrow am. 3 stack ops

QPull \rightarrow am. 1 stack op

⑦ Q Push pays for all 4 stack ops

Q Push \rightarrow am. 4 stack ops

Q Pull \rightarrow am. ① stackops

Concatenation

NDW + HEZE \rightsquigarrow NOWHERE