Dynamic Array Queue and Deque
void addBack(TYPE val);  // Add value at end of queue.
TYPE front();              // Get value at front of queue.
void removeFront();        // Remove value at front.
Queue Applications

What nodes are reachable from A?
Queue with Dynamic Array

void addBack(TYPE val); // Add value at end of queue.
TYPE front(); // Get value at front of queue.
void removeFront(); // Remove value at front.

Removal from front is expensive!
Deque (Double Ended Queue) ADT

```c
void addFront(TYPE val);
void removeFront();
TYPE front();
void addBack(TYPE val);
void removeBack();
TYPE back();
```
Deque Application

• Finite Length Undo

• Palindrome Checker (e.g. radar)
Let the partially filled block “float” & “wrap”

Allow the starting index, beg, to “float” around the underlying array! It’s no longer confined to index 0

Logical index

Absolute index

How??

Keep track of the data, arranged circularly and convert all logical indices into proper indices for the actual array!
struct ArrDeque {
    TYPE *data;       /* Pointer to data array. */
    int    size;      /* Number of elements in collection. */
    int    beg;       /* Index of first element. */
    int    cap;       /* Capacity of array. */
};

void initArrDeque(struct ArrDeque *d, int cap) {
    d->data = malloc(cap * sizeof(TYPE));
    assert(d->data != 0);
    d->size = d->beg = 0;
    d->cap = cap;
}
Adding/Removing from Back

**Add**

```
beg  size
```

**Remove**

```
beg  size
```

Adding/Removing from Back
Adding/Removing from Front

**Add**

```
  beg       size
```

**Remove**

```
  beg       size
```

Adding/Removing from Front
Elements can wrap around from beg to end
• Calculate offset: add logical (element) index to beg

\[
\text{offset} = \text{beg} + \text{logicalIndex}; \quad /* \text{logIndex} = 3, \text{offset} = 9 */
\]

• If larger than or eq to capacity, subtract capacity

\[
\text{if (offset} \geq \text{cap)}
\]

\[
\text{absoluteIndex} = \text{offset} - \text{cap};
\]

• Alternatively, use mod:

\[
/* \text{Convert logical index to absolute index. */}
\]

\[
\text{absIdx} = (\text{logicalIdx} + \text{beg}) \% \text{cap};
\]
Can we simply copy the elements to a larger array?

- Have to be careful because the wrapping is dependent on the ‘capacity’
Let’s write it
Key Changes from Dynamic Array

• Keep track of floating data with `beg` & `size`
• Wrap `beg` as necessary
• Whenever accessing a logical index, convert to absolute first
• On resize, copy to start of the new array and reset `beg`
Let’s look at some code...

```c
void addFrontDynArr(DynArr *v, TYPE val){
  if (v->size >= v->capacity)
    _dynArrSetCapacity(v, 2*v->capacity);

  v->beg = v->beg - 1;
  if(v->beg < 0)
    v->beg = v->capacity-1;

  v->data[_absoluteIndex(v, 0)] = val;
  v->size++;
}
```

- Always make sure you have space
- Wrap beg as necessary
- Don’t forget to increment size
- Update beg
- front is at logical index = 0
- Convert to proper absolute index
Let’s look at some code...

```c
void addFrontDynArr(DynArr *v, TYPE val) {
  if (v->size >= v->capacity) 
    dynArrSetCapacity(v, 2*v->capacity);
  v->beg = v->beg - 1;
  if (v->beg < 0) v->beg = v->capacity - 1;
  v->data[absoluteIndex(v, 0)] = val;
  v->size++;
}
```

Full implementation is in `dynamicArrayDeque.c`

- Always make sure you have space
- Wrap `beg` as necessary
- Don’t forget to increment size
- Convert to proper absolute index
- Front is at logical index = 0

Full implementation is in `dynamicArrayDeque.c`
# Operations Analysis

<table>
<thead>
<tr>
<th>Operation</th>
<th>Best</th>
<th>Worst</th>
<th>Ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>AddBack</td>
<td>1</td>
<td>n</td>
<td>1+</td>
</tr>
<tr>
<td>RemoveBack</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
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