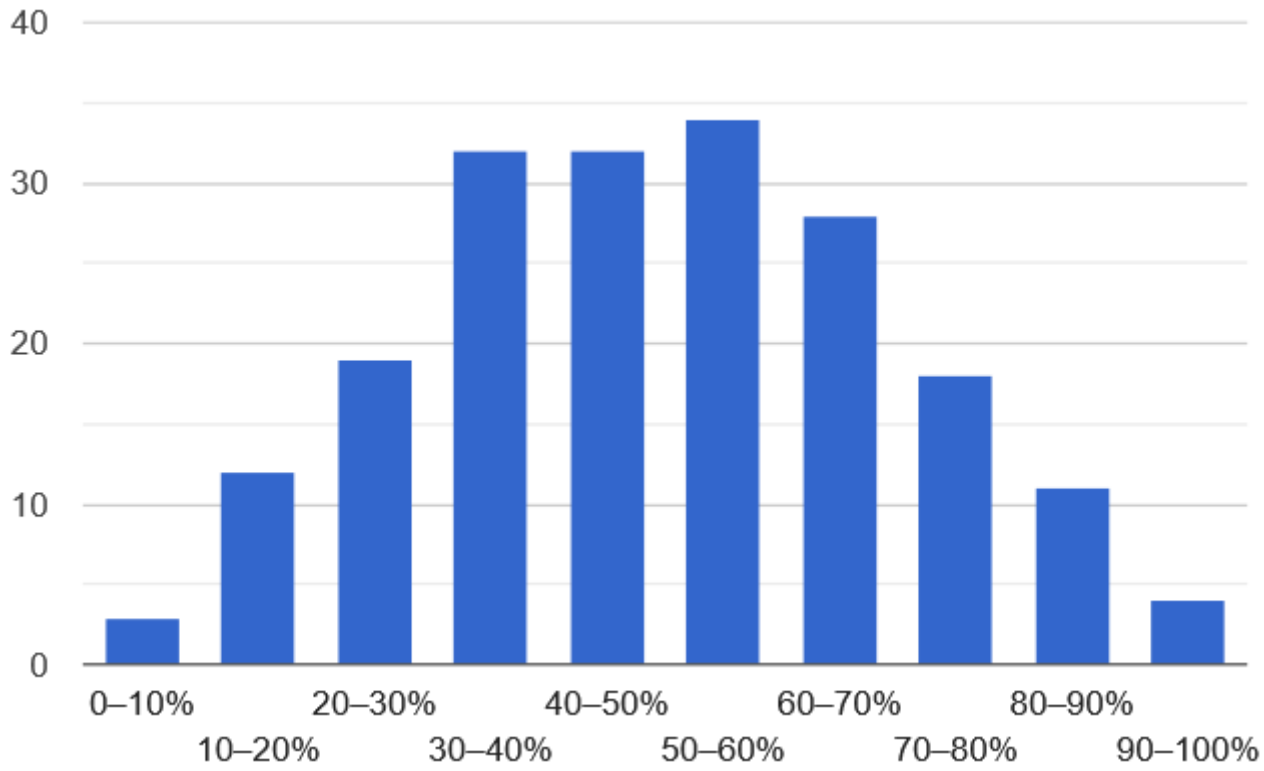
Midterm Debrief

- Pick up or view your midterms during office hours today

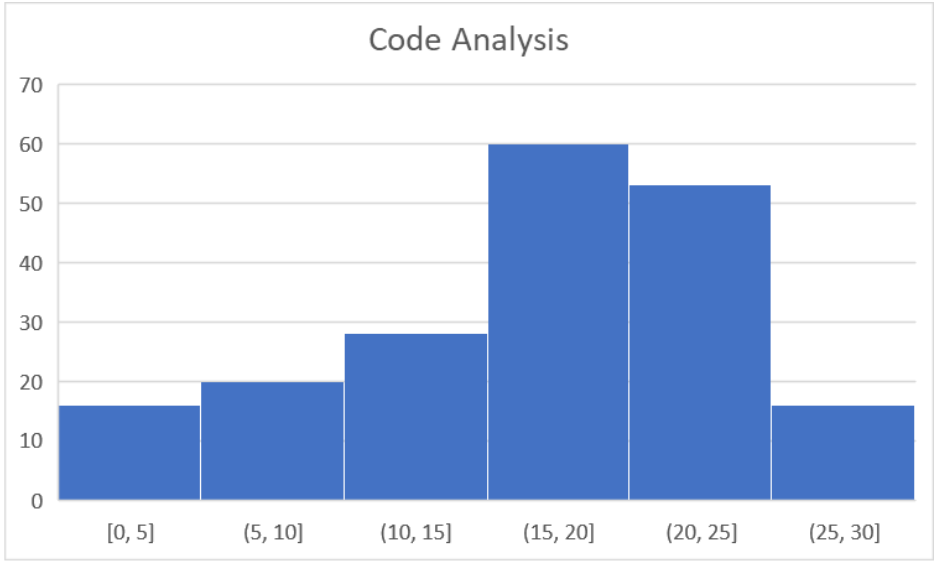
- 2:30-4:30pm in my office hours

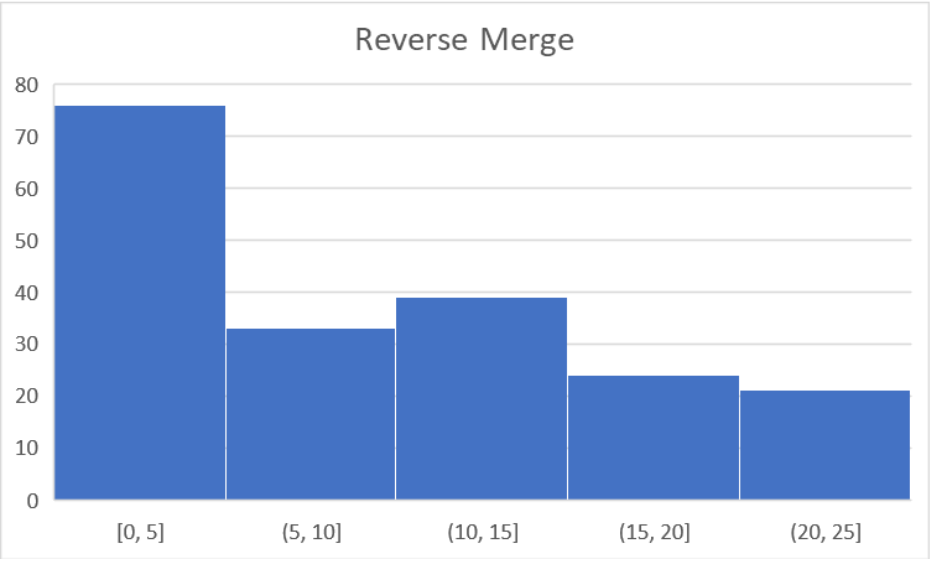
Midterm Debrief

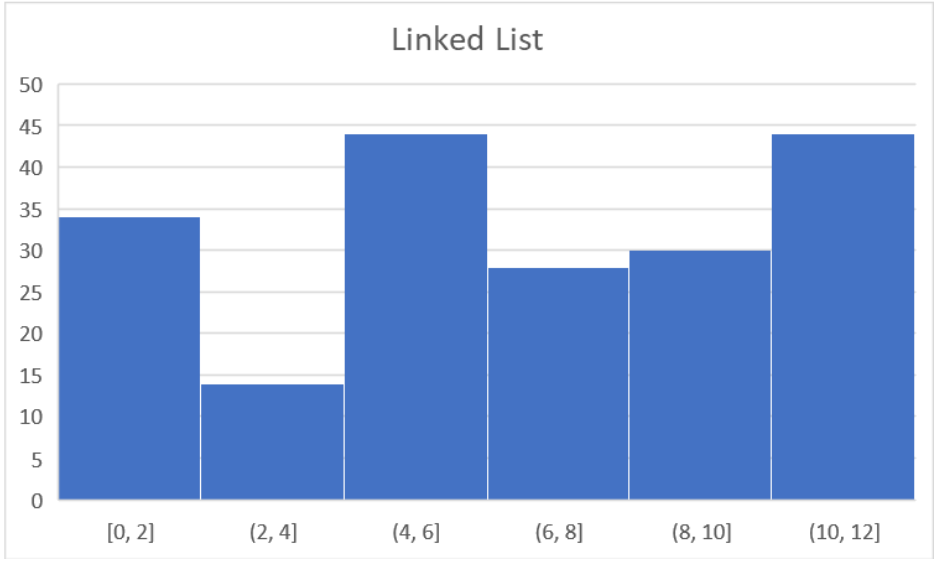
Mean Grade	38.40 / 77.00
Median Grade	38.00 / 77.00
Standard Deviation	15.66



Midterm Debrief







Studying for the finals: Goals

- Good student goals: *at least* be able to
  - Redo all exercises in class (e.g. proofs)
  - Reproduce all code in lectures on your own
  - Reproduce all assignment/midterm solutions on your own
- Great student goals: *in addition, at least* be able to
  - Teach someone else basic level tasks
  - Convert all pseudocode (e.g. in Stack lecture) to code
  - Recall details in material (e.g. quicksort worst-case run time)
- There's nothing a good final can't fix
- **The above works for most courses!**

Reproduce merge code

```
//  Pre:  arr[first..mid] and arr[mid+1..last] are sorted
//  Post:  arr[first..last] are sorted
void merge(int arr[], int first, int mid, int last) {
    int len = last-first+1;  int newArr[len];
    int left = first;  int right = mid+1;  int newPos = 0;
    while(left <= mid && right <= last) {
        if (arr[left] < arr[right]) {
            newArr[newPos++] = arr[left++];
        } else {
            newArr[newPos++] = arr[right++];
        }
    }
    //  Flush non empty piece
    arrCpy(arr + left, newArr + newPos, mid - left + 1);
    arrCpy(arr + right, newArr + newPos, last - right + 1);

    arrCpy(newArr, arr + first, len);
}
```

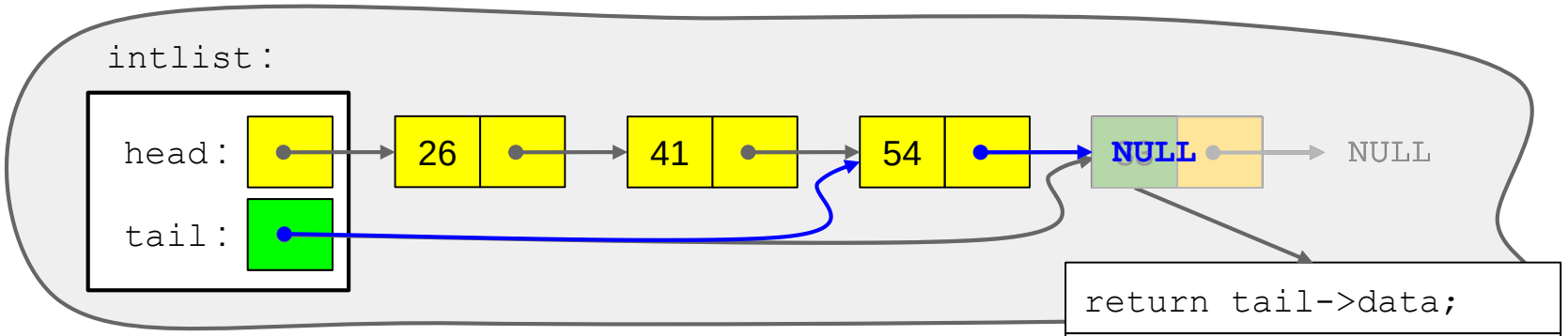
General tips

- Make a cheat sheet, even though you will not be allowed on one on the final
- Regularly review and study, even if there is no due date
  - Your brain needs time to subconsciously process material
- Ask and answer questions on Piazza
- Reward yourself for studying and learning
- Create practice questions for others or do these questions on Piazza

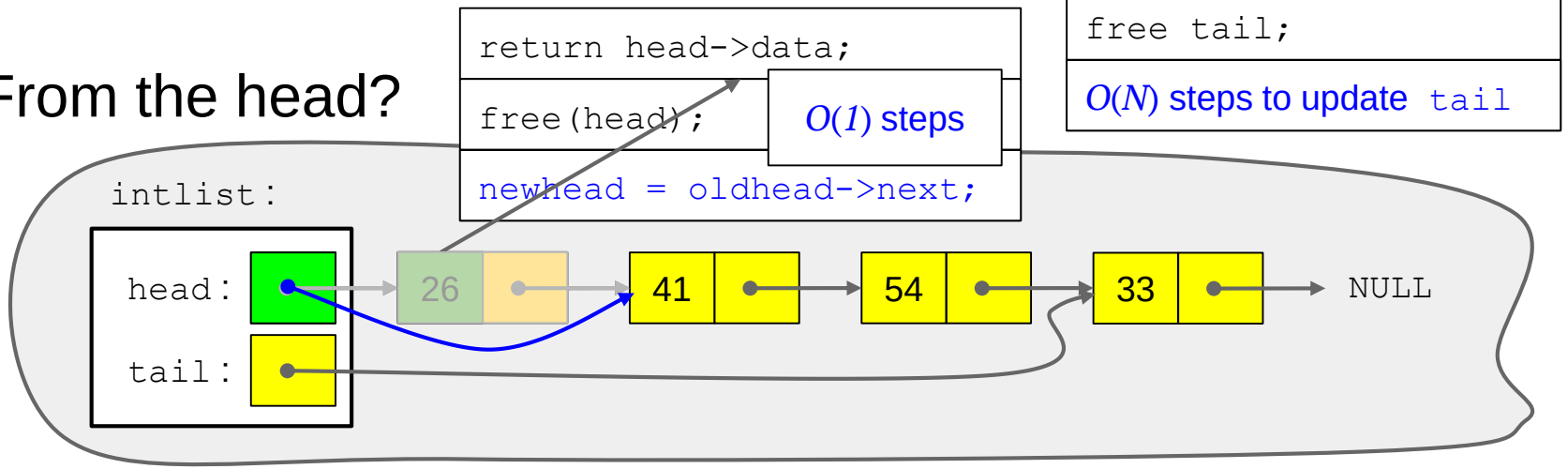
Code up `pop(S)`

Q. From which end should you remove an item?

From the tail?



From the head?



SFU

Queue ADT

CMPT 125
Mo Chen
SFU Computing Science
6/3/2020

Lecture 22

Today:

- Queue ADT
- An algorithm that uses a Queue
- Implementing a Queue (with a Linked List)
- Information Hiding & Encapsulation - Part 1

Queue ADT (Review)

Queue ADT: A *queue* is a sequence of data, but the insert and remove operations work on opposite ends of the sequence.

- order is first-in-first-out (FIFO)
- like a line-up

Used in simulations and modeling

- to model sequences of work and their processors, e.g., assembly lines
- *Operations Research* (OR)

Queue of items

A processor

Queue-Based Searching (Breadth-First Search)

Rules:

- Numbers represent elevation
- You may only traverse to adjacent grid cells that differ by no more than 2

Problem: Find all locations that are reachable from the start, and compute their distance.

Sample Map:

50	51	54	57	65	69
48	52	51	58	64	64
47	53	52	54	60	63
45	48	49	56	64	61
44	45	51	57	58	60
42	46	50	52	58	59

Algorithm:

Create an empty queue Q; enqueue start → Q

Initialize all distances ← -1 (unreachable), except distance(start) ← 0

```
while Q not empty {
        dequeue from Q → current
        if next is neighbour of current and distance(next) == -1 {
                distance(next) = distance(current) + 1
                enqueue next → Q
        }
}
```

Queue-Based Searching (Breadth-First Search)

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Algorithm:

```
Create an empty queue Q; enqueue start → Q
Initialize all distances ← -1 (unreachable), except distance(start) ← 0
while Q not empty {
        dequeue from Q → current
        if next is neighbour of current and distance(next) == -1 {
                distance(next) = distance(current) + 1
                enqueue next → Q
        }
}
```

Distance:

0	1	-1	-1	14	-1
1	2	3	-1	13	12
2	3	4	5	-1	11
3	-1	-1	6	-1	10
4	5	-1	7	8	9
5	6	-1	-1	9	10

Q: (0,0) (0,1) (1,0) (1,1) (2,0) (1,2) (2,1) (3,0) (2,2) (4,0) (2,3) (4,1) (5,0) (3,3) (5,1) ...

Dist: 0 1 1 2 2 3 3 3 4 4 5 5 5 6 6

Queue Implementation

Queue Interface:

- a sequence of data in FIFO order
- `create()`
- `enqueue(x)`
- `dequeue()`
- `isEmpty()`

Implement using a Linked List

- `create()` and `isEmpty()` are trivial
- for `enqueue(x)` and `dequeue()`, only issue is to decide which end of the list

Queue Implementation: Algorithms

```
create():
     return LLcreate();

isEmpty(Q):
     return (Q->head == NULL);

enqueue(Q, x):
     LLappend(Q, x);

dequeue(Q):
     return LLremoveHead(Q);
```

	head	tail
insert	$O(1)$	$O(1)$
remove	$O(1)$	$O(N)$

Information Hiding in C

```
typedef LL_t queue_t;

// Creates a pointer to a new empty queue.
// Returns NULL on failure.
queue_t * queue_create(void);

// Recycles a queue
void queue_destroy(queue_t * q);

// Returns 1 iff queue is empty
int queue_isEmpty(queue_t * q);

// Adds element to the back of the queue
void queue_enqueue(queue_t * q, int element);

// Removes element from the front of the queue.
// Undetermined behaviour if queue is empty
int queue_dequeue(queue_t * q);
```

An invitation for disaster!

Encourages abuse or misuse by calling the linked list functions on the type `queue_t *`.

Better would be:

```
typedef struct _queue
queue_t;
```

which hides all information.

The naming implies that we would or should call these operations only on the type `queue_t *`.

Marrying Data and Functions

Encapsulation

- bundle related data and operations together

Forge a language construct that marries data and operations together

- use a `struct`!
- make the functions part of the data type explicitly
  - called *methods*
- similar idea to an *object* in Python

Adds another level of protection against misuse

```
typedef struct _queue {
    LL_t * intlist;
} queue_t;

queue_t * queue_create(void);
void queue_destroy(queue_t * q);
int queue_isEmpty(queue_t * q);
void queue_enqueue(queue_t * q, int element);
int queue_dequeue(queue_t * q);
```

ORIGINAL

```
typedef struct _queue {
    LL_t * intlist;
    void queue_destroy(queue_t * q);
    int queue_isEmpty(queue_t * q);
    void queue_enqueue(queue_t * q, int element);
    int queue_dequeue(queue_t * q);
} queue_t;

queue_t * queue_create(void);
```

```
typedef struct _queue {
    LL_t * intlist;
} queue_t;

queue_t * queue_create(void);
void queue_destroy(queue_t * q);
int queue_isEmpty(queue_t * q);
void queue_enqueue(queue_t * q, int element);
int queue_dequeue(queue_t * q);
```

ORIGINAL

```
typedef struct _queue {
    LL_t * intlist;
    void queue_destroy(struct _queue * q);
    int queue_isEmpty(struct _queue * q);
    void queue_enqueue(struct _queue * q, int element);
    int queue_dequeue(struct _queue * q);
} queue_t;

queue_t * queue_create(void);
```

```
typedef struct _queue {
    LL_t * intlist;
} queue_t;

queue_t * queue_create(void);
void queue_destroy(queue_t * q);
int queue_isEmpty(queue_t * q);
void queue_enqueue(queue_t * q, int element);
int queue_dequeue(queue_t * q);
```

ORIGINAL

```
typedef struct _queue {
    LL_t * intlist;
    void ( * destroy) (struct _queue * q);
    int ( * isEmpty) (struct _queue * q);
    void ( * enqueue) (struct _queue * q, int element);
    int ( * dequeue) (struct _queue * q);
} queue_t;

queue_t * queue_create(void);
```

Pointer to a function rather than the function itself

Caller's notation:

```
Q->enqueue(Q, x);
```

A Look Ahead to C++

Motivated by these interface issues,

C++ evolved out of C.

- formulated by Bjarne Stroustrop in 1978

Bjarne Stroustrop

Provides the syntactic sugar for:

- information hiding
- encapsulation of data and methods
- common code re-use situations

Migrate from `struct` → `class`