[TAP:RTNHE] Where?

Administrative Details

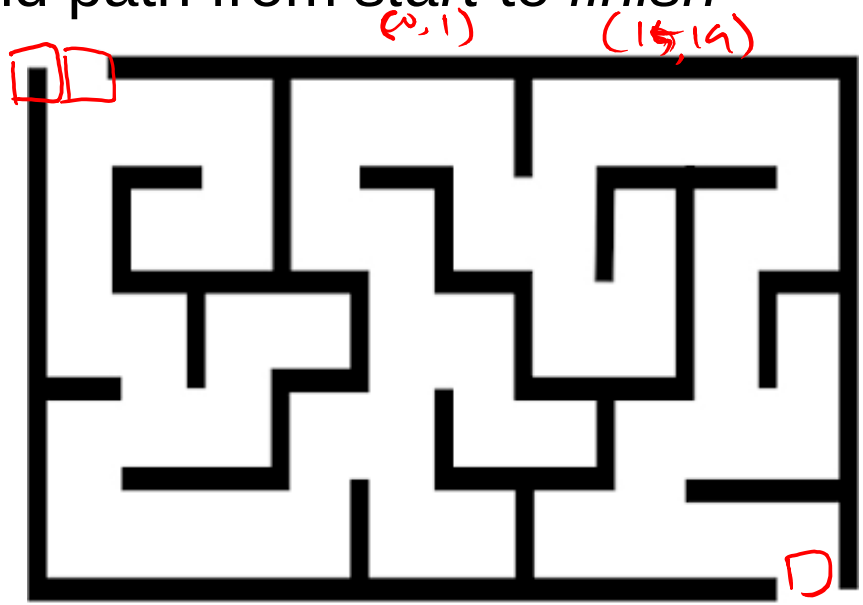
- Spring Break!

Today's Outline

- Linear Structures
  - Stack
    - Applications
  - Queue
    - Applications

Mazes

- How can we use a stack to solve a maze?
- Properties of mazes:
  - We model a maze as a 2-d array of cells
  - There is a *start* cell and one or more *finish* cells
  - Goal: Find path from *start* to *finish*



Solving Mazes

- We'll use two objects to solve our maze:
  - Position: Info about a single cell
  - Maze: Grid of Positions
- General strategy (backtracking search):
  - Use stack to keep track of path from start
  - Go one way ("push")
  - If we get stuck, go back ("pop") and try a different way
  - We will eventually either find a solution or exhaust all possibilities

Position Class

- Represent position in maze as (x,y) coordinate
- Instance variables: int row, int col, boolean visited, boolean open
- Methods:
  - Getters and setters
  - `equals()`
  - `toString()`

Maze Class

- Represent position in maze as (x,y) coordinate
- Instance variables: Position start, Position finish, Position[][] board
- Methods:
  - Getters and setters
  - `toString()`
  - `Position nextAdjacent(Position current)`

```
public Position nextAdjacent(Position cur) {
    Position next = board[cur.getRow()-1][cur.getCol()];
    if (next.isOpen() && !next.isVisited()) {
        return next;
    }

    next = board[cur.getRow()][cur.getCol()+1];
    if (next.isOpen() && !next.isVisited()) {
        return next;
    }

    next = board[cur.getRow()+1][cur.getCol()];
    if (next.isOpen() && !next.isVisited()) {
        return next;
    }

    next = board[cur.getRow()][current.getCol()-1];
    if (next.isOpen() && !next.isVisited()) {
        return next;
    }

    return null;
}
```

// N

// E

// S

// W

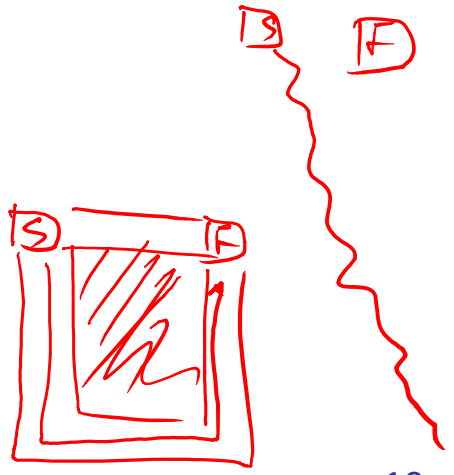
RecSolver Class

```
public static boolean solve(Maze maze, Position cur){
    if (cur.equals(maze.finish()))
        return true;

    cur.visit();
    Position next = maze.nextAdjacent(cur);
    while (next != null){
        if (solve(maze, next)){
            System.out.print(next + " ");
            return true;
        }
        next = maze.nextAdjacent(cur);
    }
    return false;
}
```

```
main() {
    solve(maze, maze.start());
```

IterSolver Class

```
public static boolean solve(Maze maze){
    Stack<Position> path = new StackList<Position>();

    Position cur = maze.start();
    cur.visit();
    path.push(cur);
    while(!path.empty() && !path.peek().equals(maze.finish())){
        Position next = maze.nextAdjacent(path.peek());
        if(next != null){
            next.visit();
            path.push(next);
        } else {
            path.pop();
        }
    }
    if(!path.empty())
        System.out.println(path);
    return !path.empty();
}
```

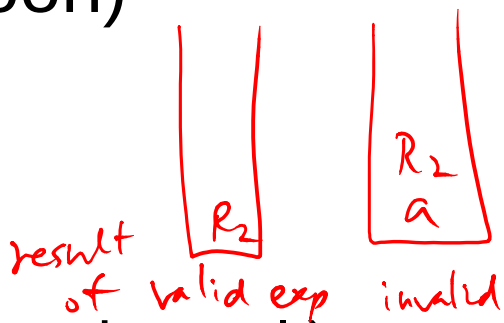


Evaluating Arithmetic Expressions

- Computer programs regularly use stacks to evaluate arithmetic expressions
- Example: x*y+z

$(z+(x*y)) \rightarrow (z(xy*)+) \rightarrow zxy*+$

  - First rewrite as xy*z+ (we'll look at this rewriting process in more detail soon)
  - Then:
    - push x
    - push y
    - * (pop twice, multiply popped items, push result)
    - push z
    - + (pop twice, add popped items, push result)



Converting Expressions

- We (humans) primarily use “infix” notation to evaluate expressions
  - (x+y)*z
- Computers traditionally used “postfix” (also called Reverse Polish) notation
  - xy+z*
  - Operators appear after operands, parentheses not necessary
- How do we convert between the two?
  - Compilers do this for us

Converting Expressions

- Example: x*y+z*w
- Conversion
  1) Add full parentheses to preserve order of operations

     ((x*y)+(z*w))

  2) Move all operators (+-*/) after operands

     ((xy*)(zw*)+)

  3) Remove parentheses

     xy*zw*+

Today's Outline

- Linear Structures
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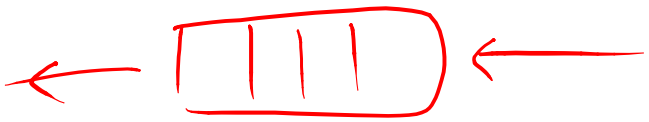
Queue

- Examples: Lines at grocery store
- What methods do we need to define?
  - Queue interface methods
- New terms (only) associated with stacks
  - Enqueue = insert from the back
  - Dequeue = remove from the front
  - peek = look up the first element



Implementation (in structure5)

- Queue interface
  - Defines enqueue/dequeue/peek methods
- 3 classes implementing the ~~stack~~ Queue interface:
  - QueueArray
    - Object[] data, int head, int count
    - tail = (head + count) % data.length
  - QueueVector
    - Vector data
    - Add/remove from tail
  - QueueList
    - SLL data
    - Add/remove from *head*

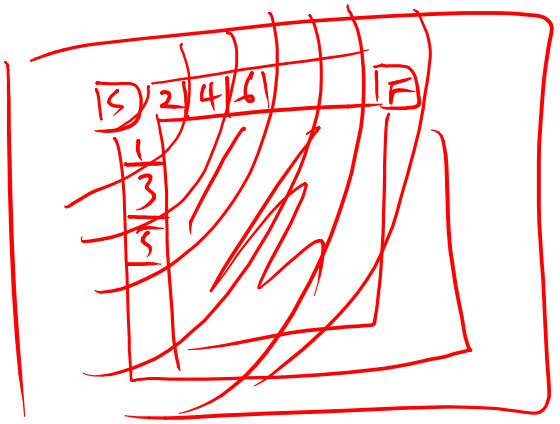
+ O(1) en/dequeue
- fixed size
- potentially wasted space

+/- enqueue O(1) (O(n) with array capacity)
- dequeue O(n)
+ resizable
- potentially wasted space

+ en/dequeue O(1)
+ resizable

Position Class

- Represent position in maze as (x,y) coordinate
- Instance variables: int row, int col, boolean visited, boolean open, Position parent;
- Methods:
  - Getters and setters
  - `equals()`
  - `toString()`



Maze Class

- Represent position in maze as (x,y) coordinate
- Instance variables: Position start, Position finish, Position[][] board
- Methods:
  - Getters and setters
  - `toString()`
  - `Position nextAdjacent(Position current)`

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QueueSolver Class

```
public static boolean solve(Maze maze) {
    Queue<Position> queue = new QueueList<Position>();

    Position current = maze.start();
    queue.enqueue(current);
    current.visit();

    while(!queue.isEmpty()) {
      current = queue.dequeue();
      if(current.equals(maze.finish())){
          System.out.println(current.toPathString());
          return true;
      }

      //enqueue all neighbors
      Position neighbor=null;
      while((neighbor=maze.nextAdjacent(current))!=null) {
          neighbor.setParent(current);
          neighbor.visit();
          queue.enqueue(neighbor);
      }
    }
    return false;
```