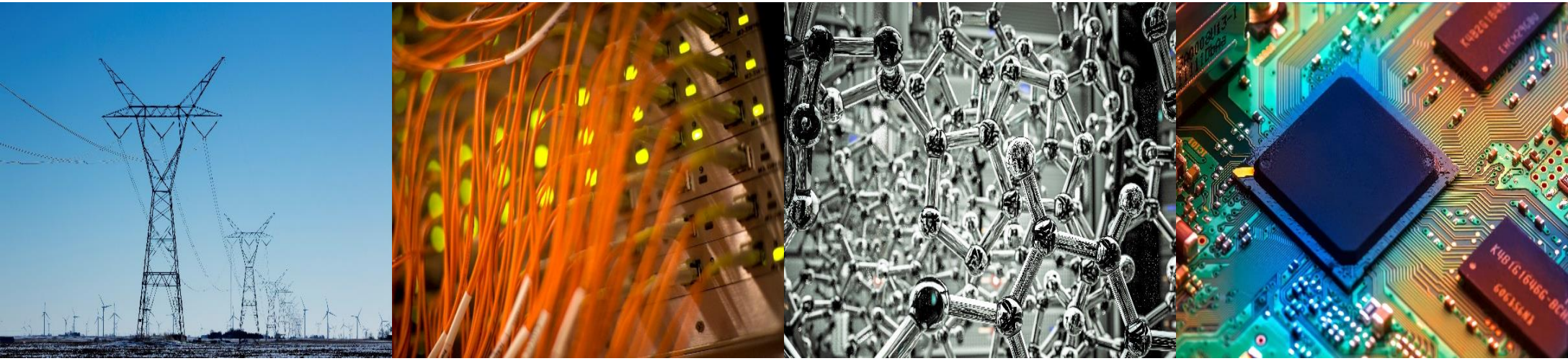
ECE 220 Computer Systems & Programming

Lecture 13 – Recursion with backtracking, C to LC-3 Conversion

October 10, 2024



- Quiz4 is next week
- MT2 study materials posted
- Informal Early Feedback

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Recursion Recap

- Solving a problem by **calling itself** on smaller pieces of data
- Must have at least 1 **base case** and at least 1 **recursive case**
- Similar to recurrence (using loops) but can result in **simpler implementation**
- Can incur **heavy overhead** on the Run-Time Stack (Good vs. Bad Recursion)

Recursion with Backtracking: n-Queen Problem

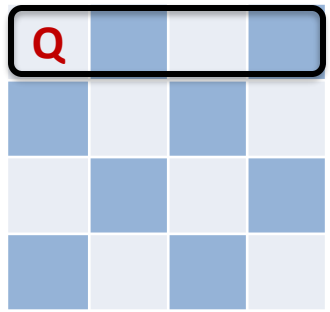
1. Find a safe column (from left to right) to place a queen, **starting at row 0**;
2. If we find a safe column, make recursive call to place a queen on the next row;
3. If we cannot find one, backtrack by returning from the recursive call to the previous row and find a different column.

	0	1	2	3
0		Q		
1				Q
2	Q			
3			Q	

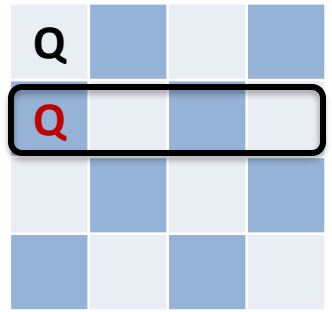
0	1	0	0
0	0	0	1
1	0	0	0
0	0	1	0

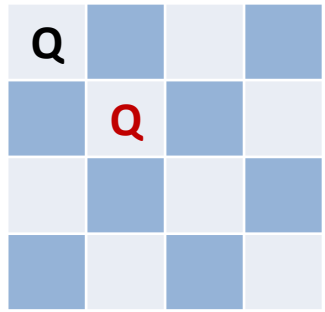
Example: 4x4 n-Queen

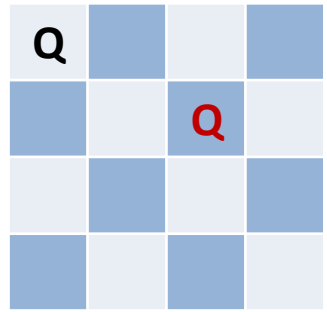
row 0:



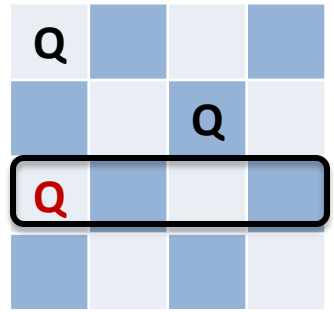
row 1:

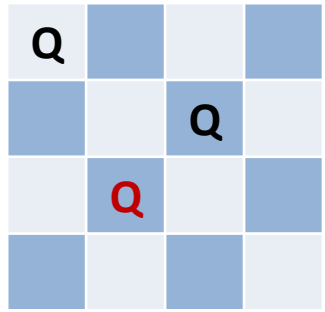


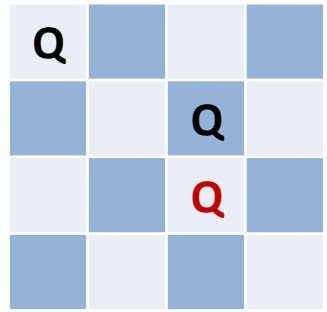


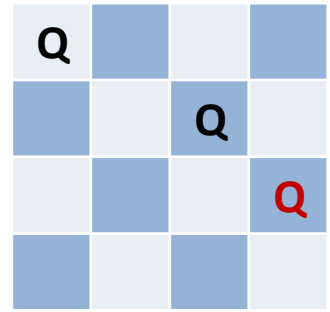


row 2:

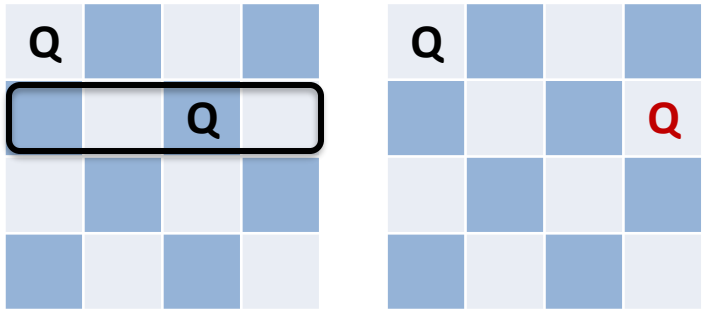




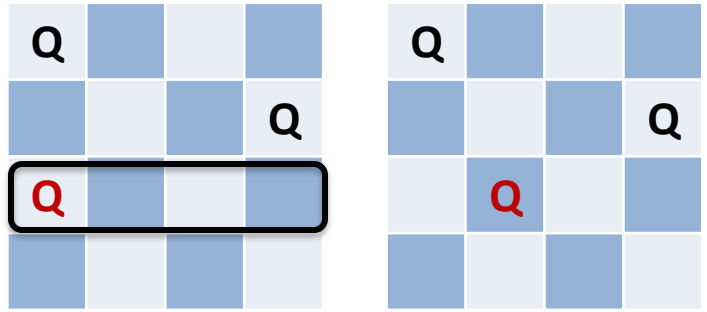




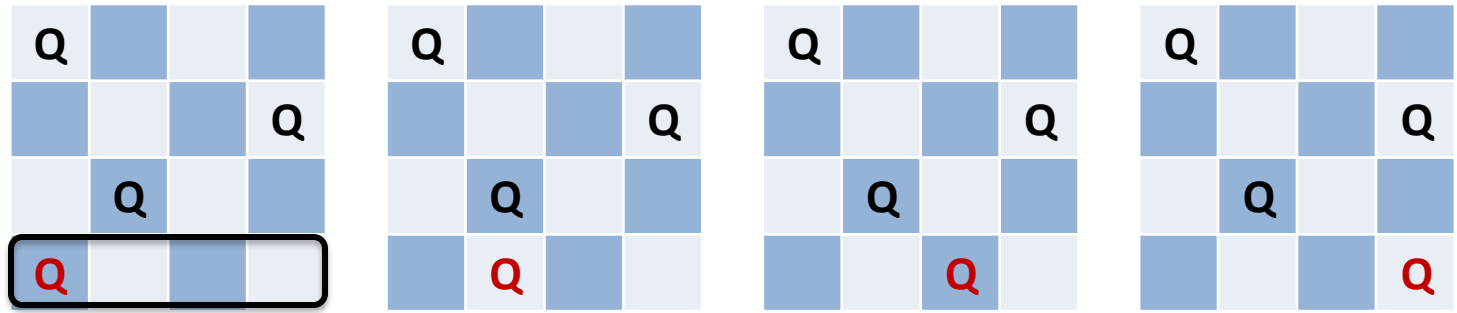
Backtrack to row 1 and make a new choice:



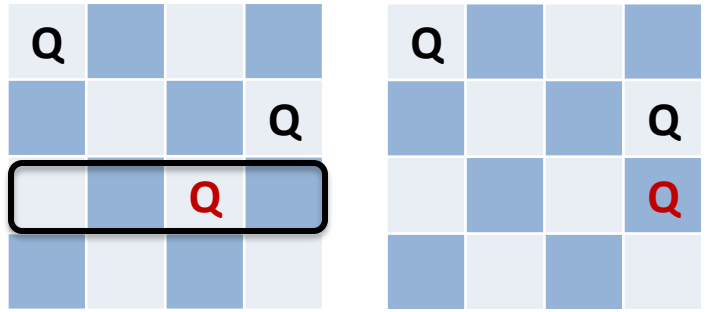
row 2:



row 3:

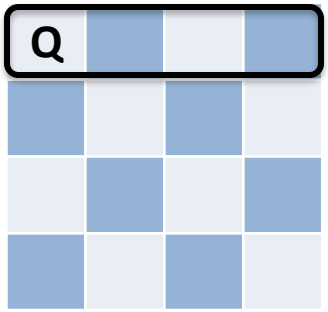


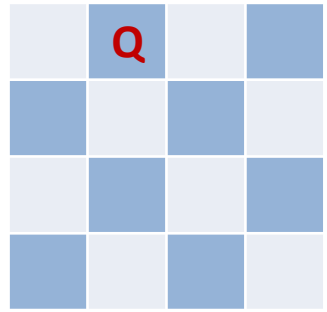
Backtrack to row 2 and make a new choice:



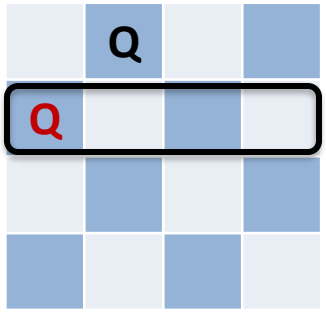
(Backtrack to row 1, but no columns left)

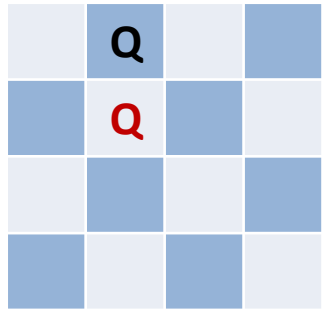
Backtrack to row 0 and make a new choice:

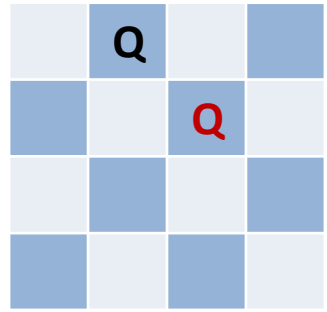


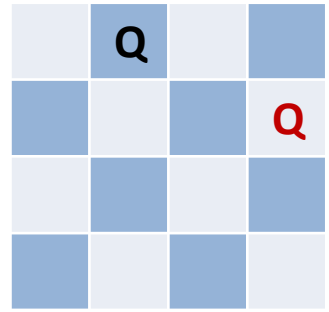


row 1:

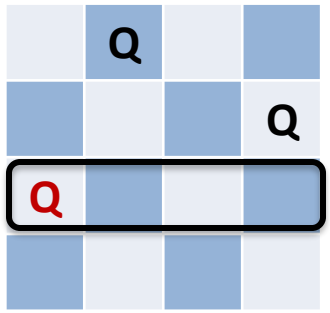




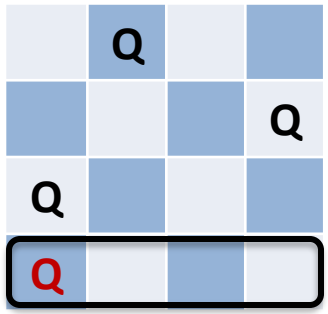


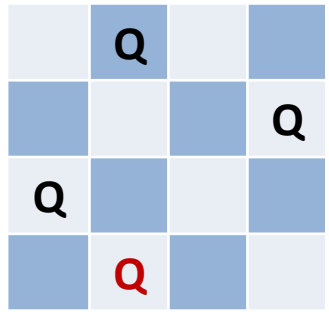


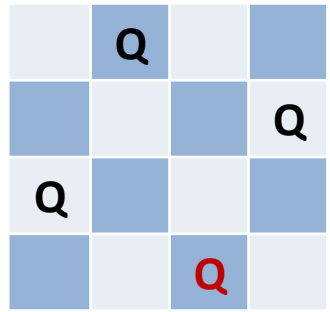
row 2:



row 3:







/* isSafe() is a helper function to check whether it's safe to place a queen at board[row][col].
   If it's safe, return 1; otherwise, return 0. */

```
int isSafe(int board[N][N], int row, int col){



}
```

Recursion with Backtracking Template

```
bool solve (configuration conf){
   if (no more choices) /*base case*/
      return (config is goal state);

   for(all available choices){
      try one choice c;
      /*recursively solve after making choice*/
      ok = solve(config with choice c made);
      if (ok)
         return true;
      else
         unmake choice c;
   }

   return false; /*tried all choices and no solution found*/
}
```

```
int nqueen(int board[N][N], int row){

        /*base case - reach solution, no more rows to place queen*/
        if(                                  )
                return 1;

        /*recursive case with backtracking*/
        int c;
        for(c=0;____________;c++){ /*find a safe col to place queen*/
                /*if col 'c' is safe, place queen here and then solve
                        subsequent steps recursively*/
                if(isSafe(                                    ) == 1){

                        board[       ][      ] = 1;

                        /*continue to solve the next step*/
                        if(nqueen(                          ) == 1)
                                        return 1;

                        /*could not solve subsequent steps, backtrack*/
                        board[       ][      ] = 0;
                }
        }
        return________;
}
```