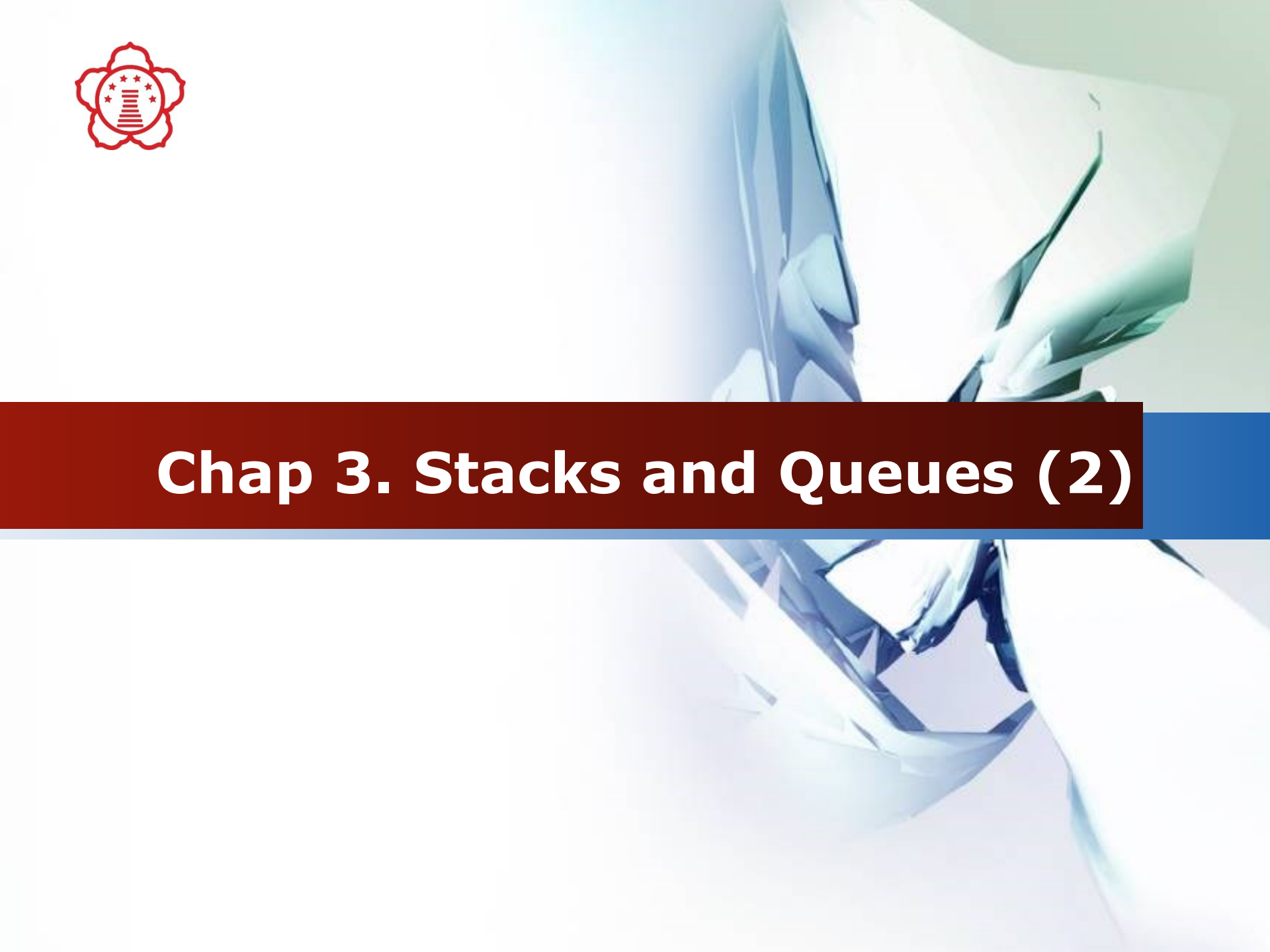

Chap 3. Stacks and Queues (2)

Contents

KUT

Chapter 3. Stacks And Queues

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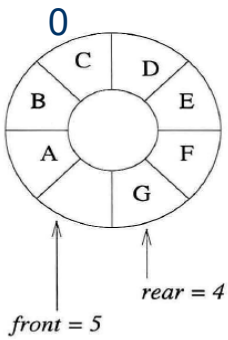
3.5 A Mazing Problem

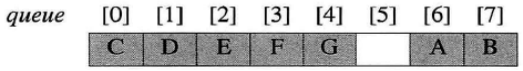
3.6 Evaluation of Expressions

3.7 Multiple Stacks and Queues

3.4 Circular Queues Using Dynamically Allocated Arrays

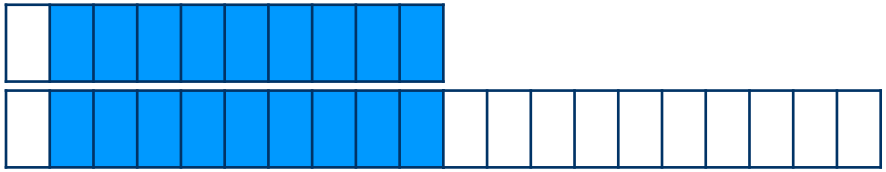


(a) A full circular queue

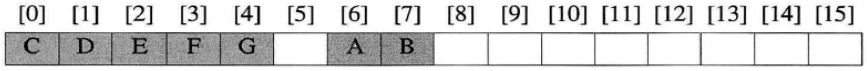


front = 5, *rear* = 4

(b) Flattened view of circular full queue

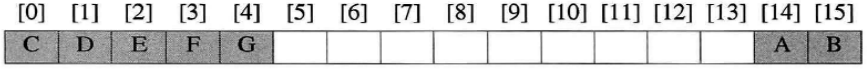


최악의 경우 이동



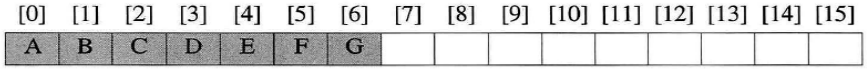
front = 5, *rear* = 4

(c) After array doubling



front = 13, *rear* = 4

(d) After shifting right segment



front = 15, *rear* = 6

(e) Alternative configuration

Figure 3.7: Doubling queue capacity

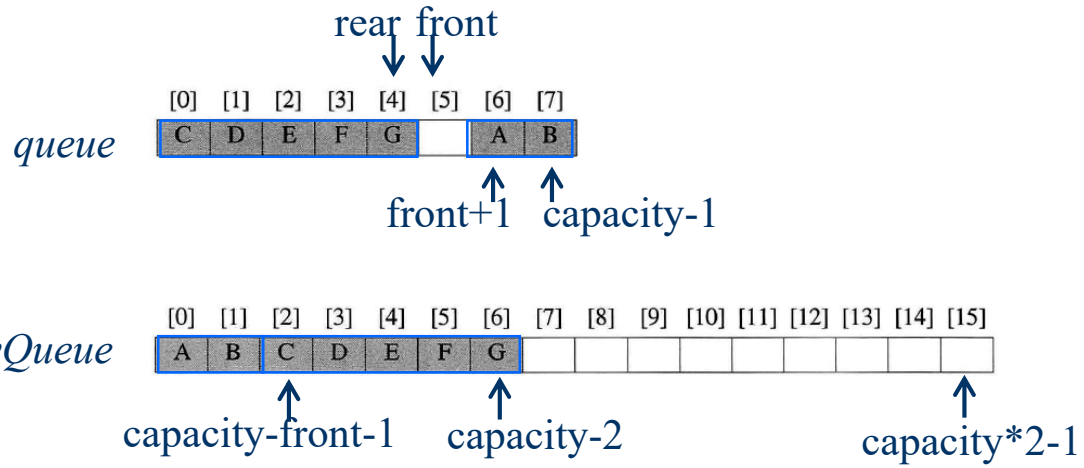
3.4 Circular Queues Using Dynamically Allocated Arrays

❖ Figure 3.7 (b)→(e)

(1) Create a new array *newQueue* of twice the capacity.

(2) Copy the second segment (i.e., the elements *queue* [*front* +1] through *queue* [*capacity* −1]) to positions in *newQueue* beginning at 0.

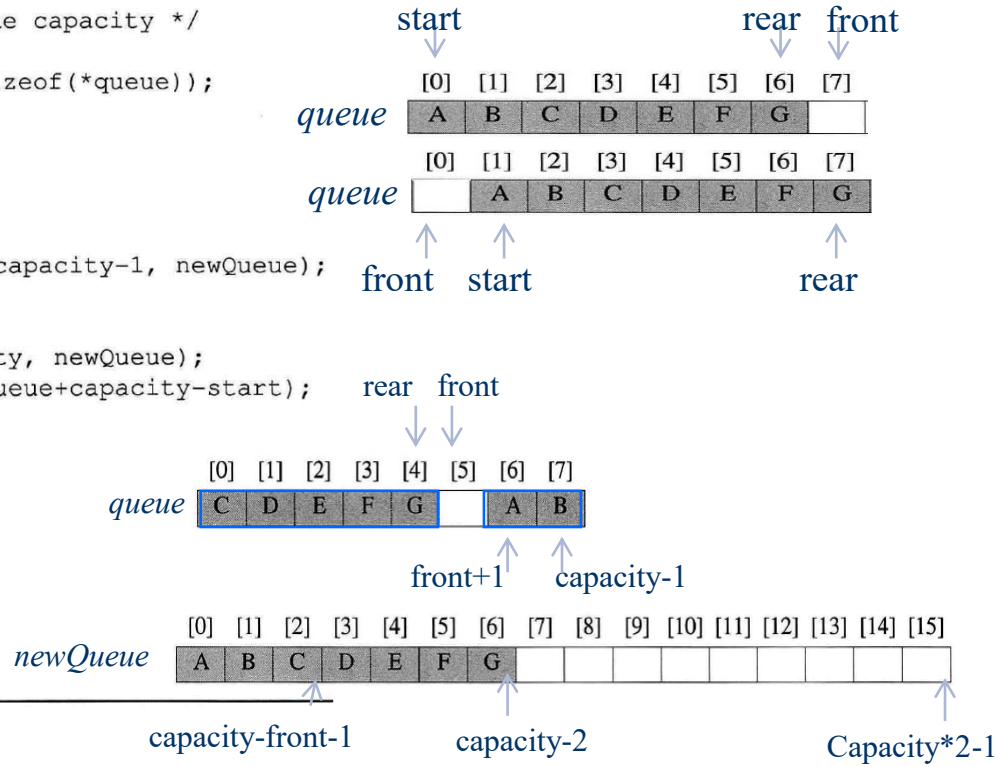
(3) Copy the first segment (i.e., the elements *queue* [0] through *queue* [*rear*]) to positions in *newQueue* beginning at *capacity* −*front*−1.



3.4 Circular Queues Using Dynamically Allocated Arrays

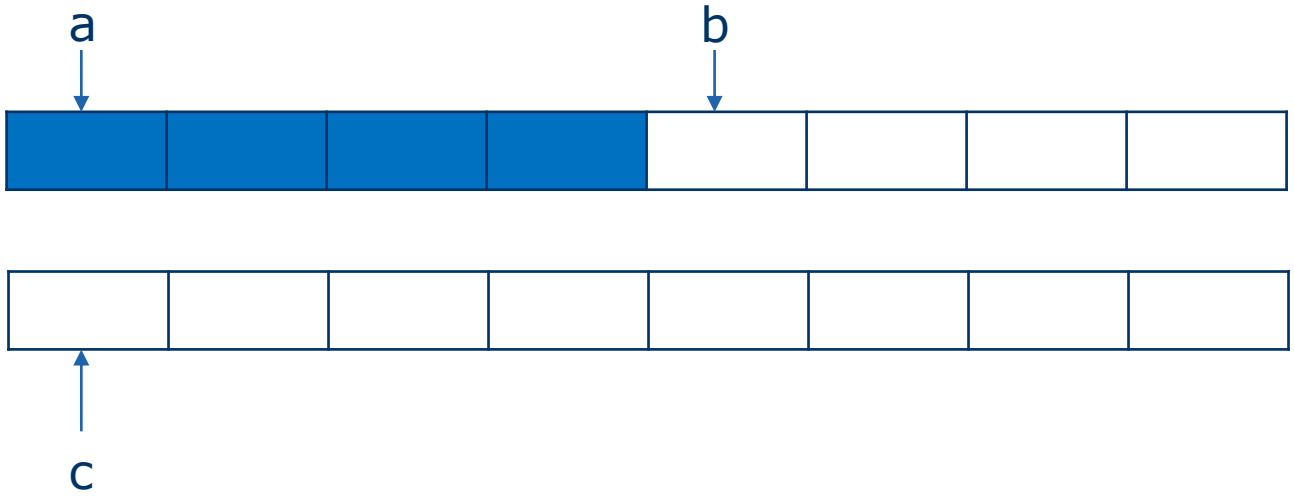
```
void queueFull()
{   int start;
    /* allocate an array with twice the capacity */
    element* newQueue;
    MALLOC(newQueue, 2 * capacity * sizeof(*queue));

    /* copy from queue to newQueue */
    start = (front+1)  % capacity;
    if (start  <  2)
       /* no wrap around */
       copy(queue+start, queue+start+capacity-1, newQueue);
    else
    {/* queue wraps around */
       copy(queue+start, queue+capacity, newQueue);
       copy(queue, queue+rear+1, newQueue+capacity-start);
    }

    /* switch to newQueue */
    front = 2 * capacity - 1;
    rear = capacity - 2;
    capacity *= 2;
    free(queue);
    queue = newQueue;
}
```

Program 3.10: Doubling queue capacity



3.4 Circular Queues Using Dynamically Allocated Arrays

```
void copy( element *a, element *b, element *c)
{
      while( a != b )
      *c++ = *a++;
}
```



Add to a circular queue

```
void addq(element item)
{/* add an item to the queue */
        rear = (rear + 1) % capacity;
        if (front == rear) {
                queueFull();                    /* double capacity */
                queue[++rear] = item;
        }
        else queue[rear] = item;
}
```

Report (until 27th September)

1. What is problem when we make a new Circular Queue with front =-1 and rear = -1.
2. Even though Queue size is Max space in a Circular Queue, why dose the Circular Queue uses only Max-1 space

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제출일 : 2023년 9월 27일

3.5 A Mazing Problem

- **Rat in a maze**
  - Experimental psychologists train rats to search mazes for food

- **For us, a nice application of *stacks***
  - Searching the maze for an entrance to exit path.

Implementation in C

Representation of a maze

- *A two-dimensional array,* ***maze***
- 0 : the open paths, 1 : the barriers

maze[12,15]

Assumptions

- Rat starts at the top le
  exits at the bottom rig

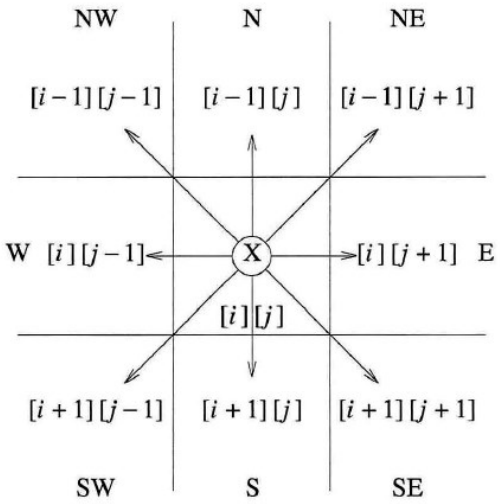
entrance

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

exit

Implementation in C

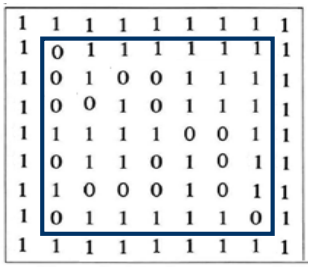
- **The current location of the rat in the maze**
  - *maze*[*row*][*col*]
- **The possible *8 moves* from the current position**



Implementation in C

- **Not every position has eight neighbors.**
  - If [*row*, *col*] is on a border, then less than eight.

- **To avoid checking for boarder conditions**
  - We can surround the maze by a boarder of ones.
  - **< *m* × *p* maze >**
    - (*m*+2) × (*p*+2) array, ***maze***
    - entrance : *maze*[1][1]
    - exit : *maze*[*m*][*p*]



Implementation in C

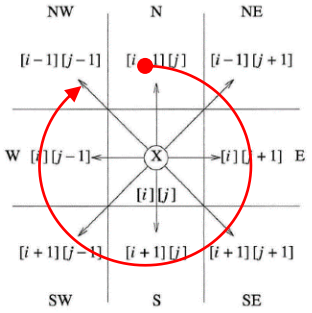
- **Predefining the possible directions to move in an array *move***

```
typedef struct {
        short int vert;
        short int horiz;
} offsets;
offsets move[8]; /*array of moves for each direction* /
```

The position of the next move, *maze*[*nextRow*][*nextCol*]

```
nextRow = row+ move[dir] .vert;
nextCol = col + move[dir] .horiz;
```

Name	Dir	*move[dir].vert*	*move[dir].horiz*
N	0	−1	0
NE	1	−1	1
E	2	0	1
SE	3	1	1
S	4	1	0
SW	5	1	−1
W	6	0	−1
NW	7	−1	−1



Implementation in C

- **Since we do not know which choice is best,**
  - we save our current position and
  - arbitrarily pick a possible move.
- **By saving our current position,**
  - we can *return to it* and *try another path* if we take a hopeless path.
- **We examine the possible moves**
  - starting from the north and moving clockwise.

Implementation in C

- **Maintaining a second 2D array, *mark***
  - to record the maze positions already checked
  - initialize the *mark*'s entries to *zero*
  - When we visit a position *maze*[*row*][*col*], we change *mark*[*row*][*col*] to *one*

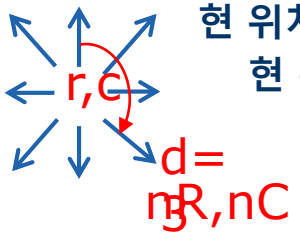
1	1	1	1	1	1	1	1	1
1	0	1	1	1	1	1	1	1
1	0	1	0	0	1	1	1	1
1	0	0	1	0	1	1	1	1
1	1	1	1	1	0	0	1	1
1	0	1	1	0	1	0	1	1
1	1	0	0	0	1	0	1	1
1	0	1	1	1	1	1	0	1
1	1	1	1	1	1	1	1	1

maze

0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

mark

Implementation in C



현 위치 (r, c)에서 탐색방향<8 이고 경로가 발견되지 않은 한 다음을 반복
현 위치 (r, c) 와 방향 d에서 계산한 다음 위치 (nR, nC)에 대해

① if 출구인 경우
경로발견!

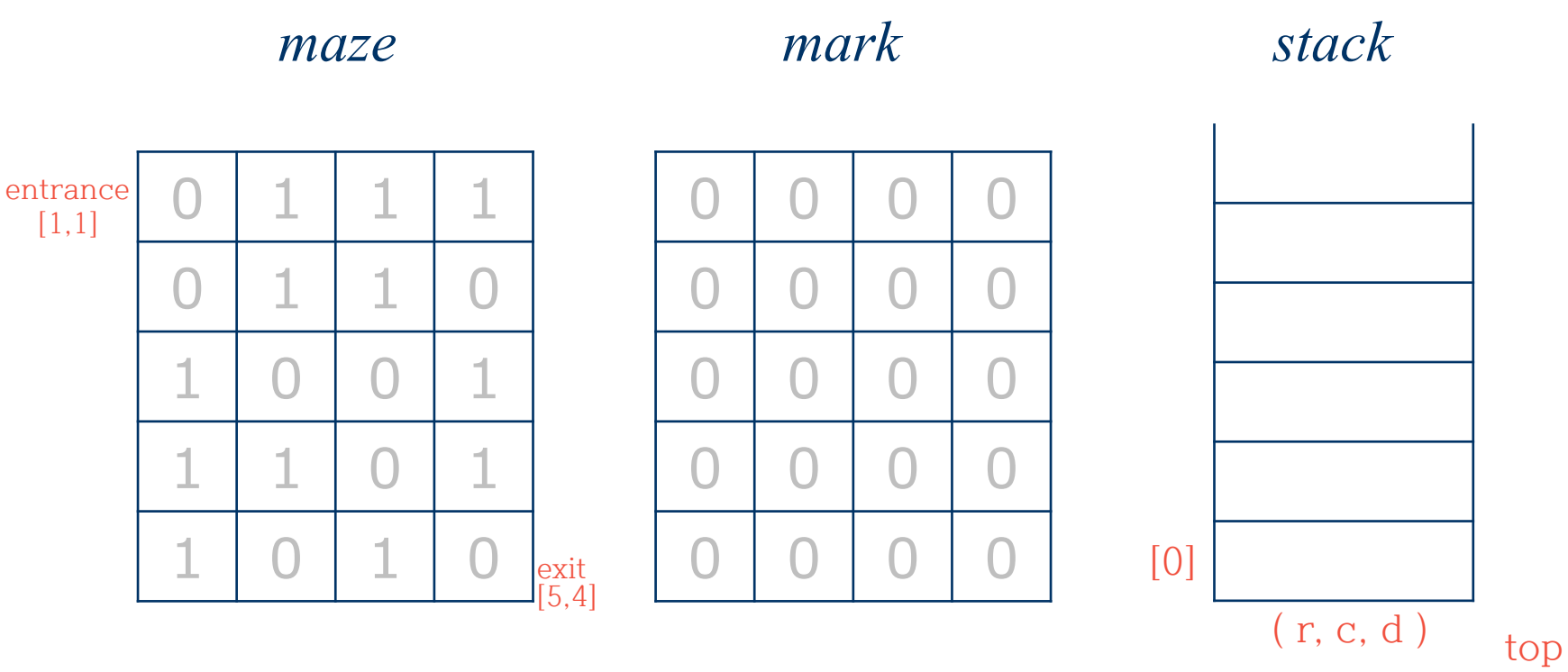
② else if 이동가능하고 이전에 방문하지 않은 경우
push(백트래킹 후 탐색할 위치와 방향) // push(r, c, ++d)
다음위치(nR, nC)에 방문했음을 표시
다음위치 (nR, nC) 으로 이동

③ else
탐색방향증가 // ++d

현 위치에서 탐색방향==8 이면 스택에서 돌아갈 위치를 가져와서
위의 과정을 반복, 스택이 empty이면 경로 발견 실패

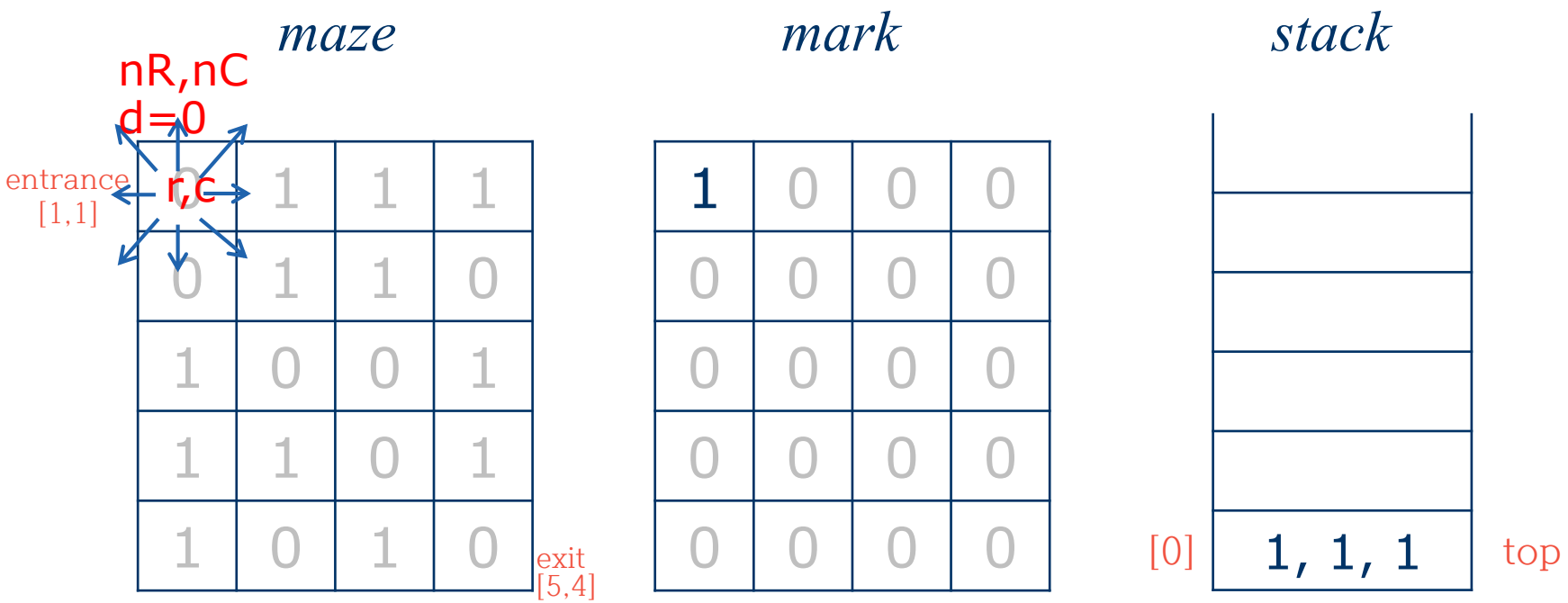
Q1. 언제 push를 수행하는가?
Q2. 언제 pop을 수행하는가

Maze Search : Example



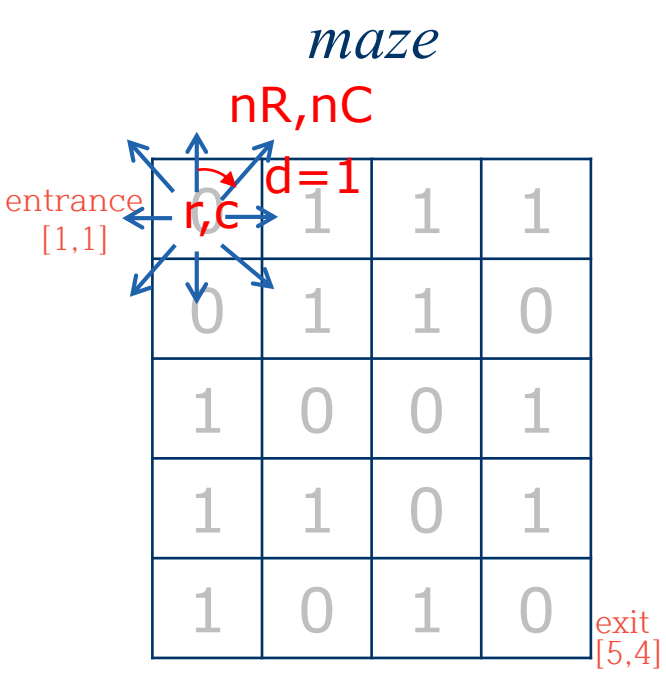
Program initialization

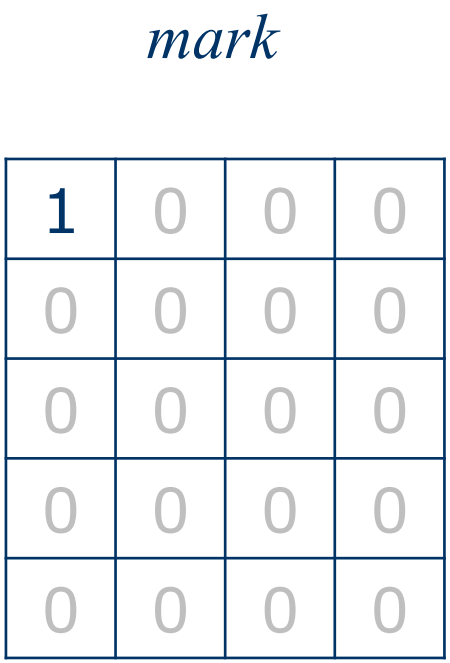
Maze Search : Example

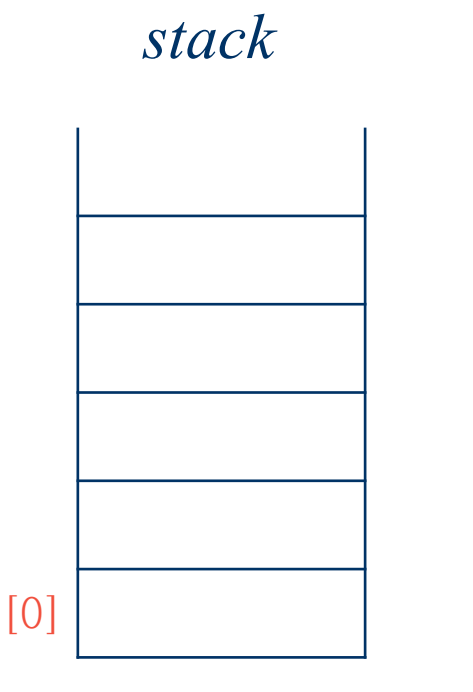


Initialization of function path()

Maze Search : Example

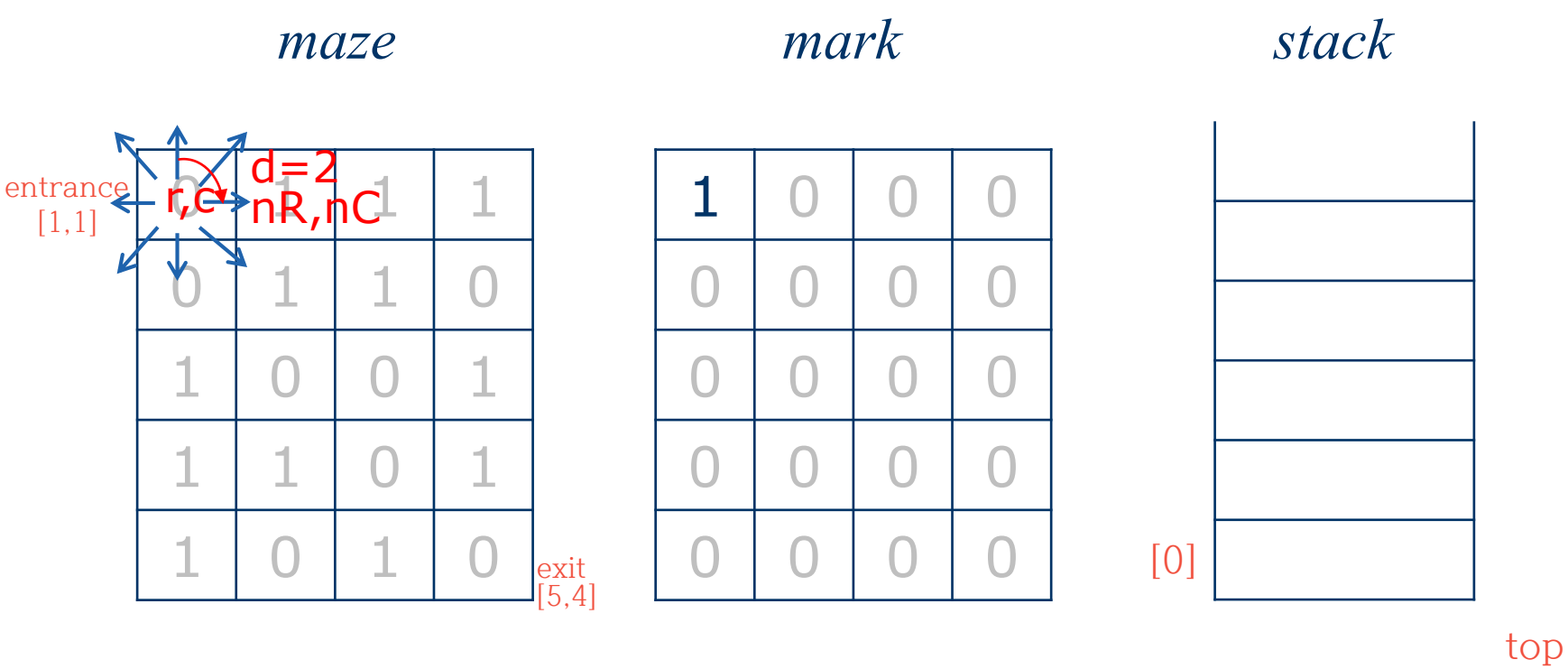




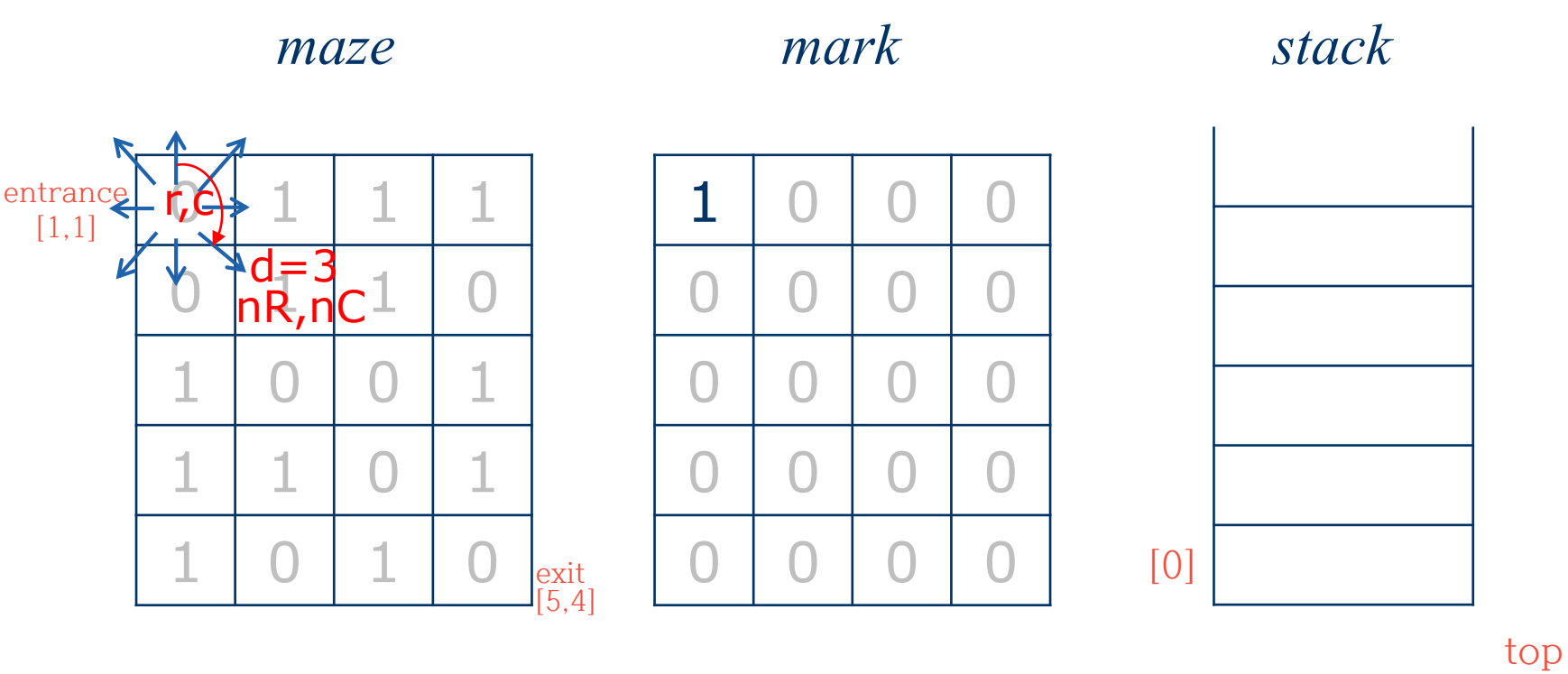


pop()
(r, c, d) = (1, 1, 1)

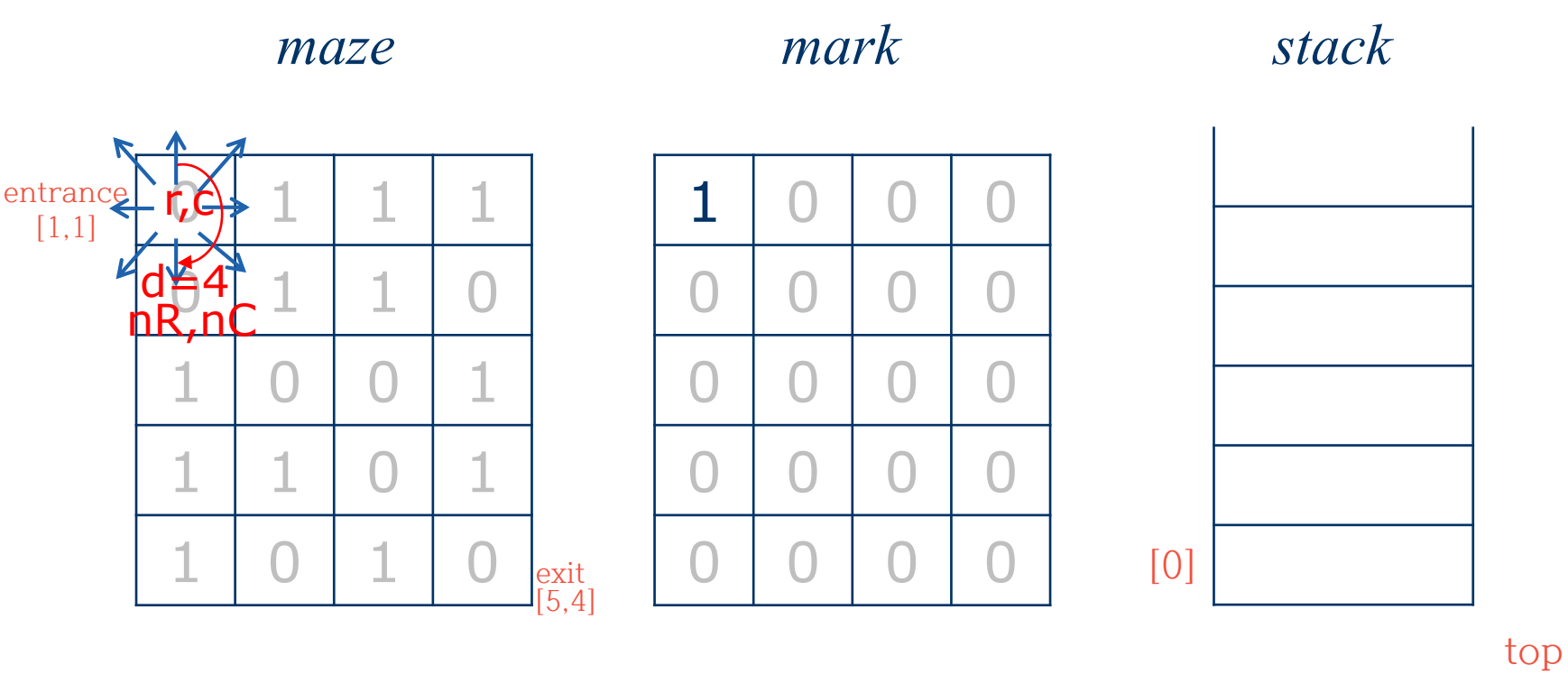
Maze Search : Example



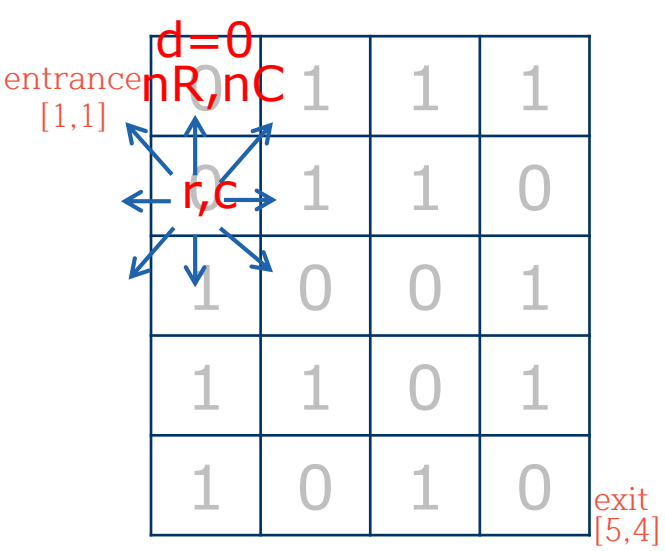
Maze Search : Example



Maze Search : Example

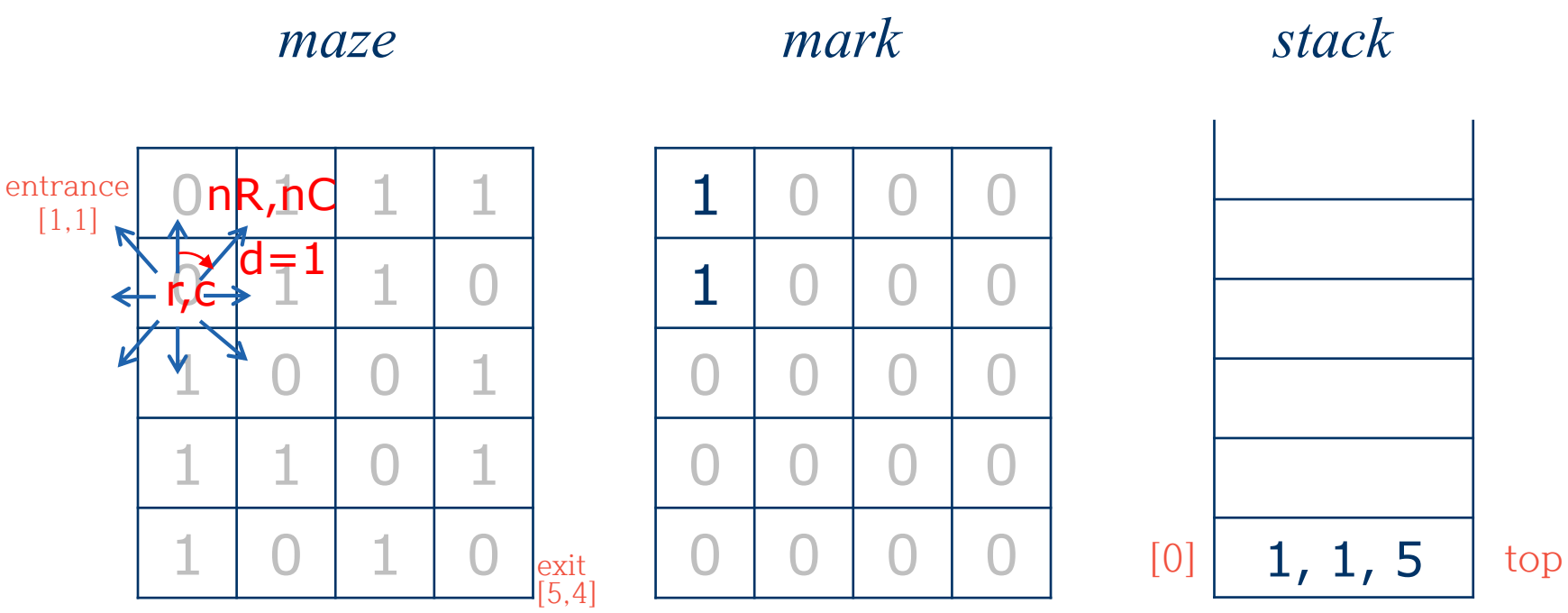


Maze Search : Example

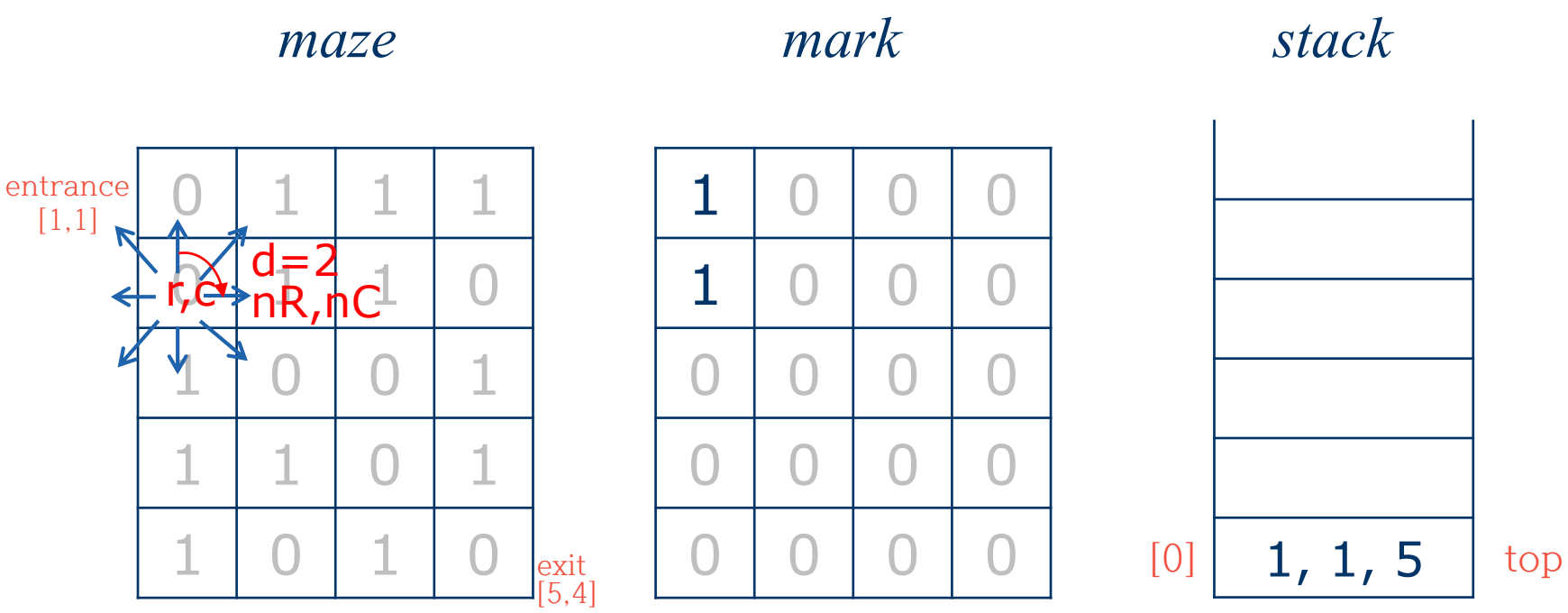


push(1, 1, 5)
(1, 2) 방문, (r, c, d) = (1, 2, 0)

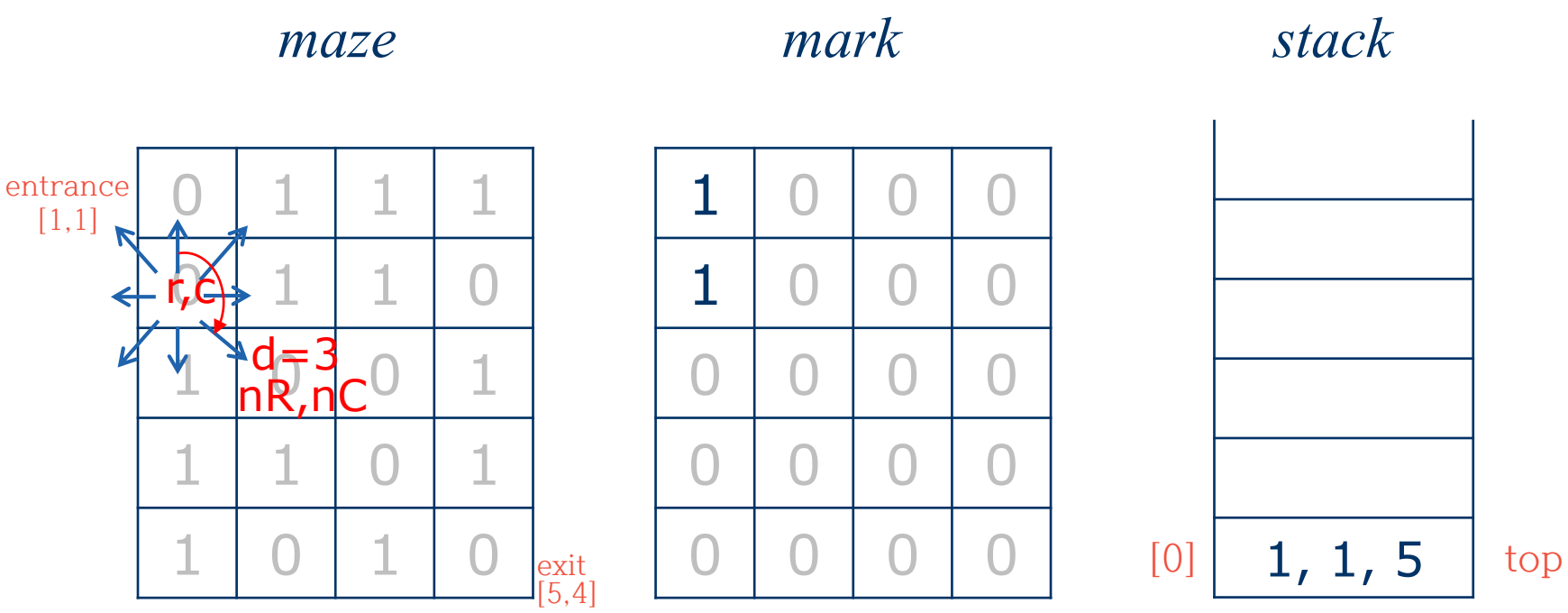
Maze Search : Example



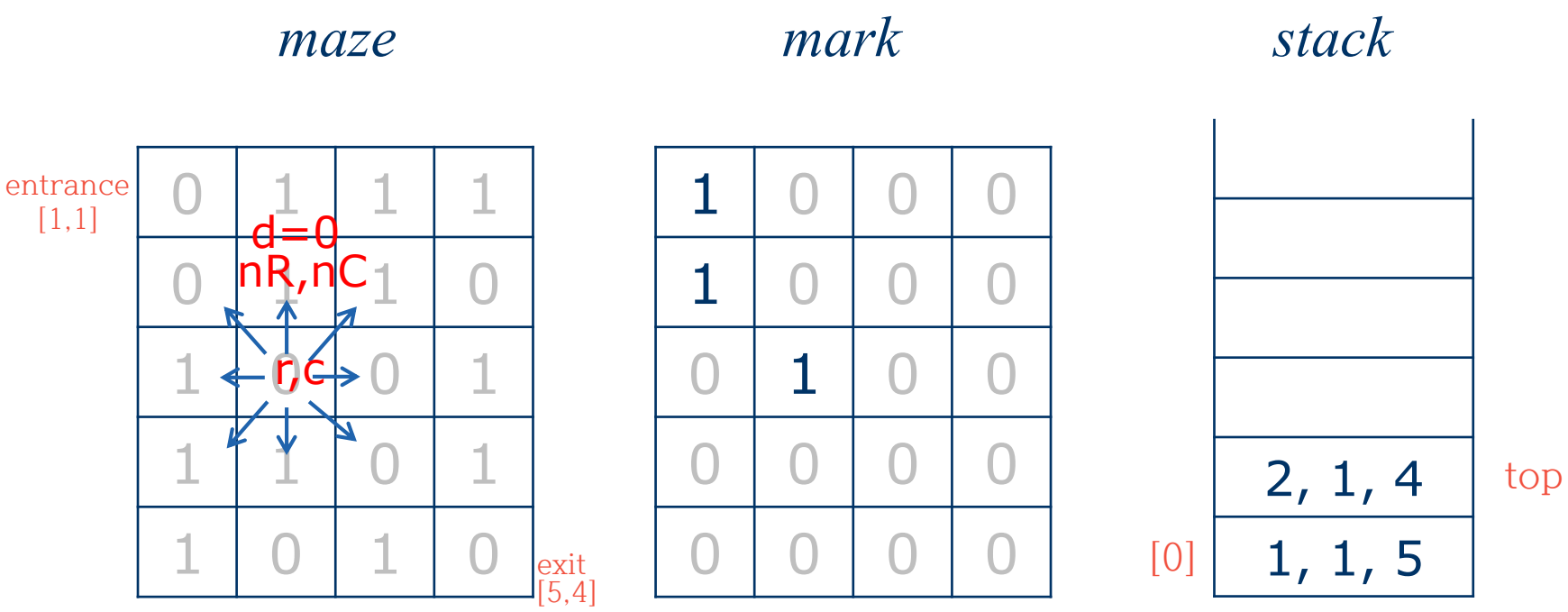
Maze Search : Example



Maze Search : Example

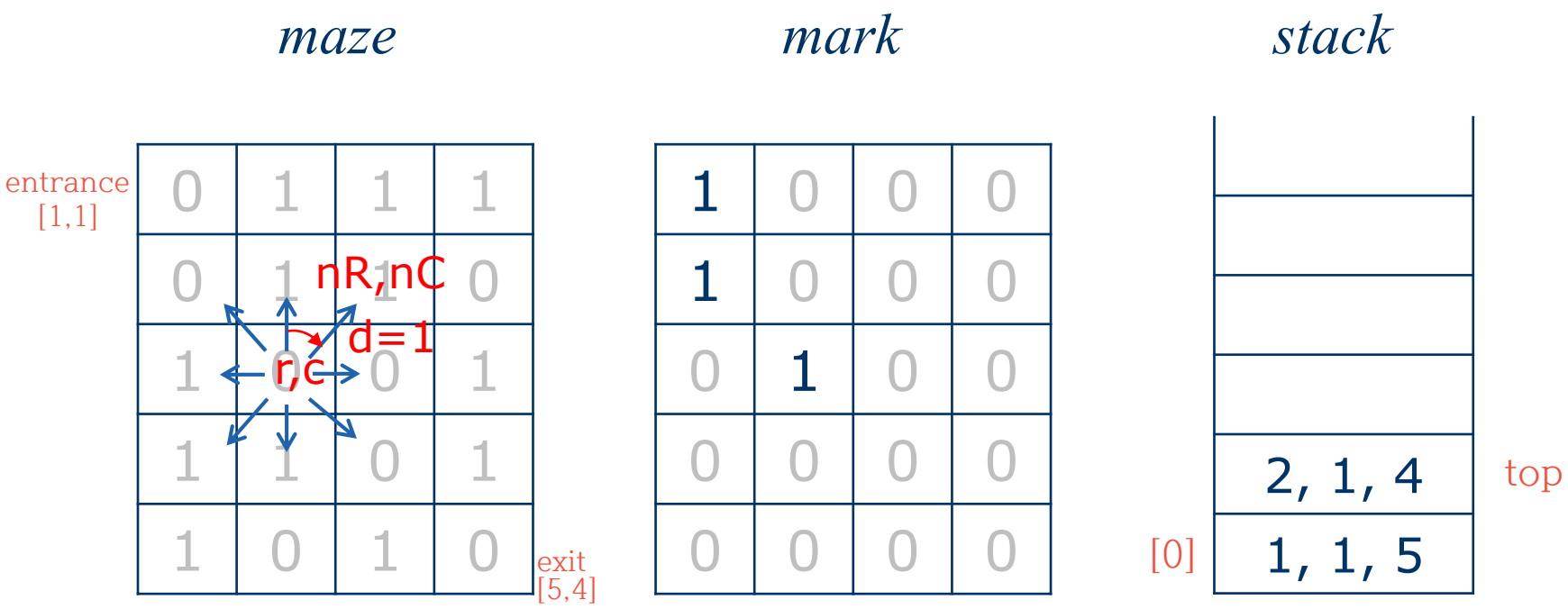


Maze Search : Example

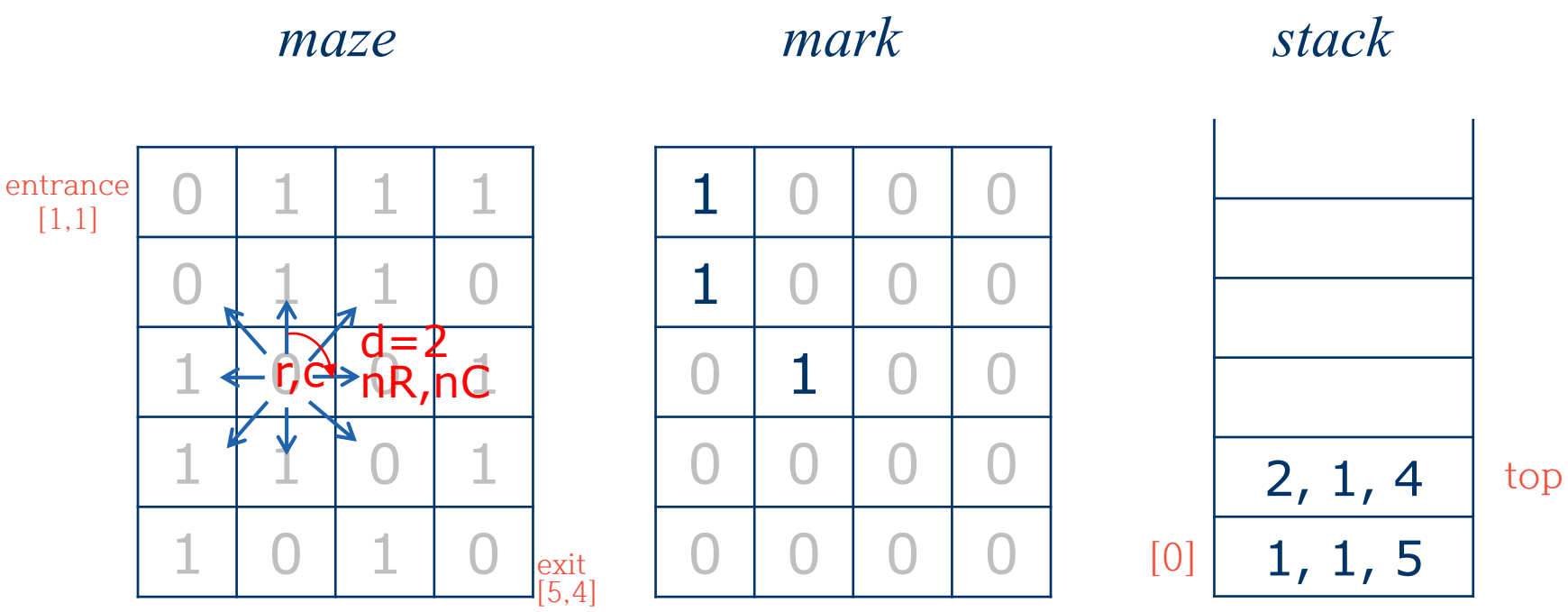


push(2, 1, 4)
(3, 2) 방문, (r, c, d) = (3, 2, 0)

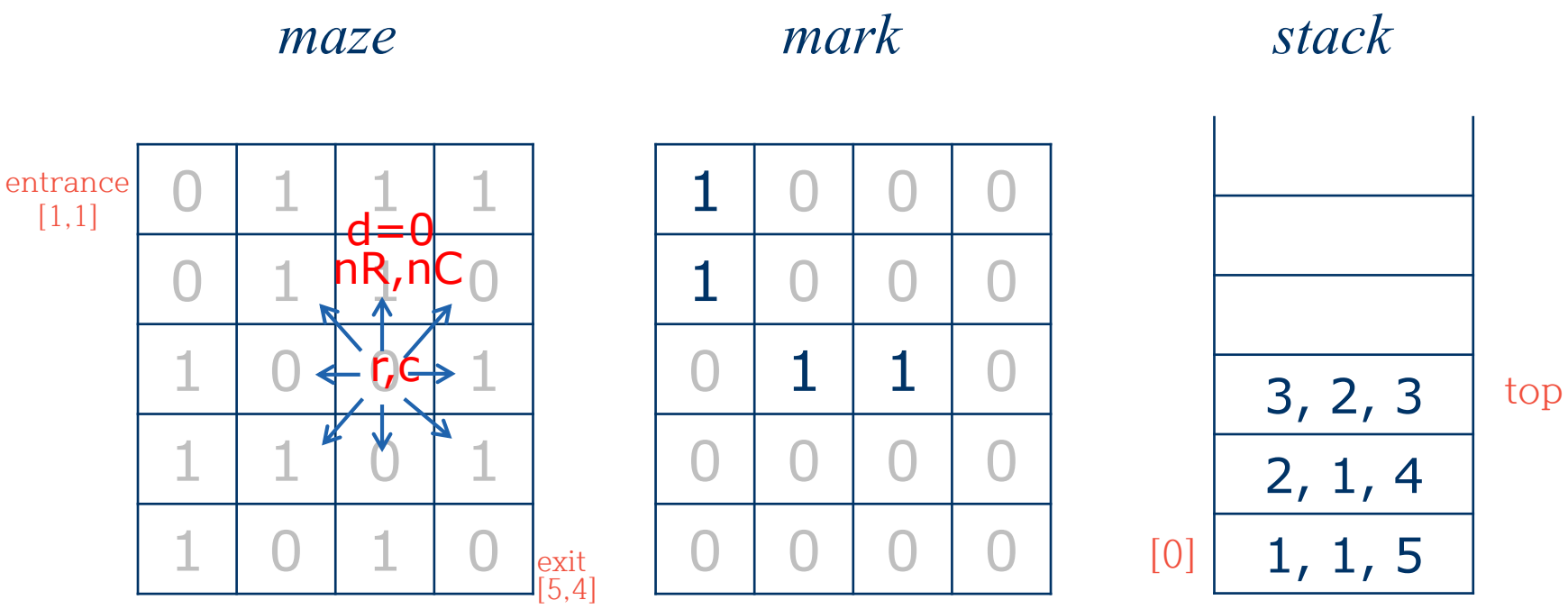
Maze Search : Example



Maze Search : Example

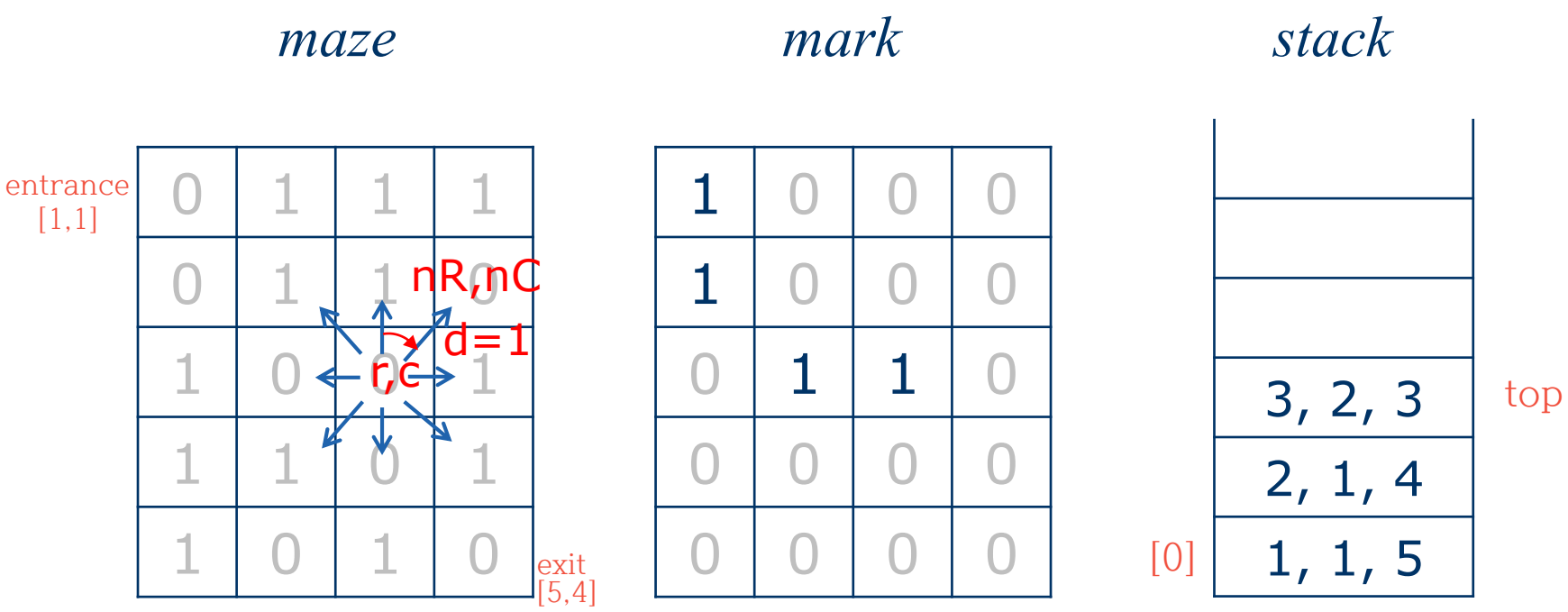


Maze Search : Example

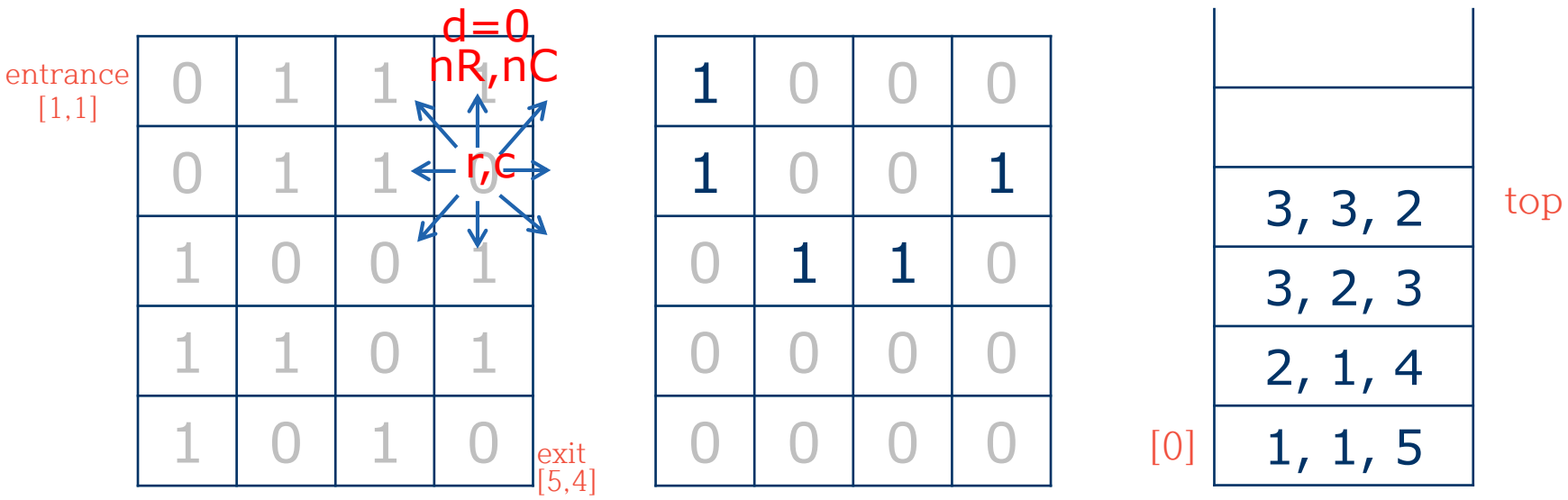


push(3, 2, 3)
(3, 3) 방문, (r, c, d) = (3, 3, 0)

Maze Search : Example

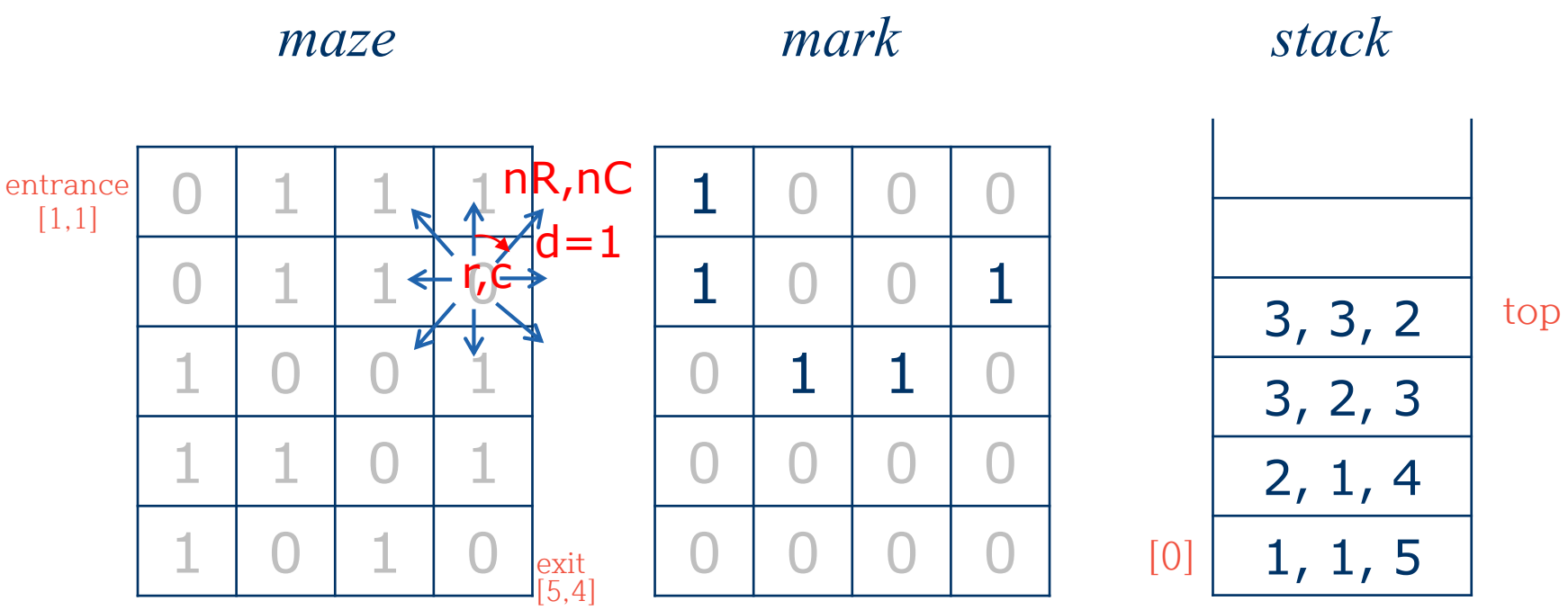


Maze Search : Example

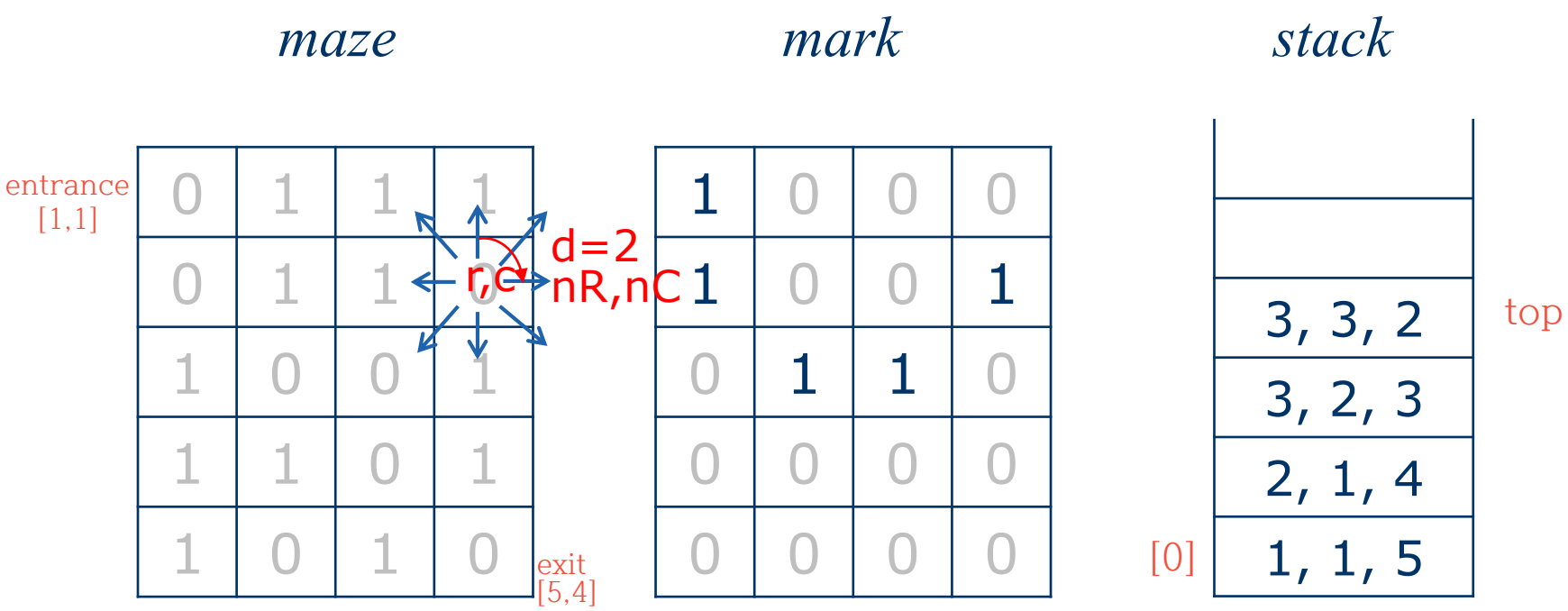


push(3, 3, 2)
(2, 4) 방문, (r, c, d) = (2, 4, 0)

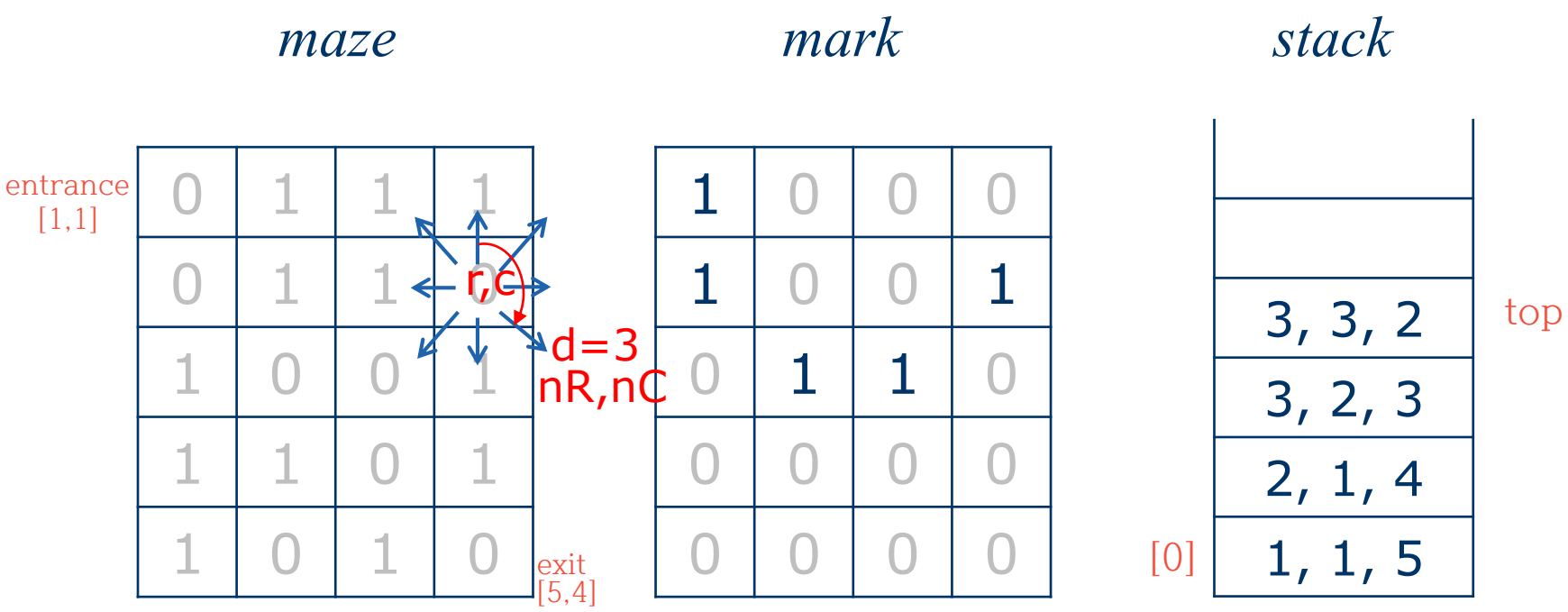
Maze Search : Example



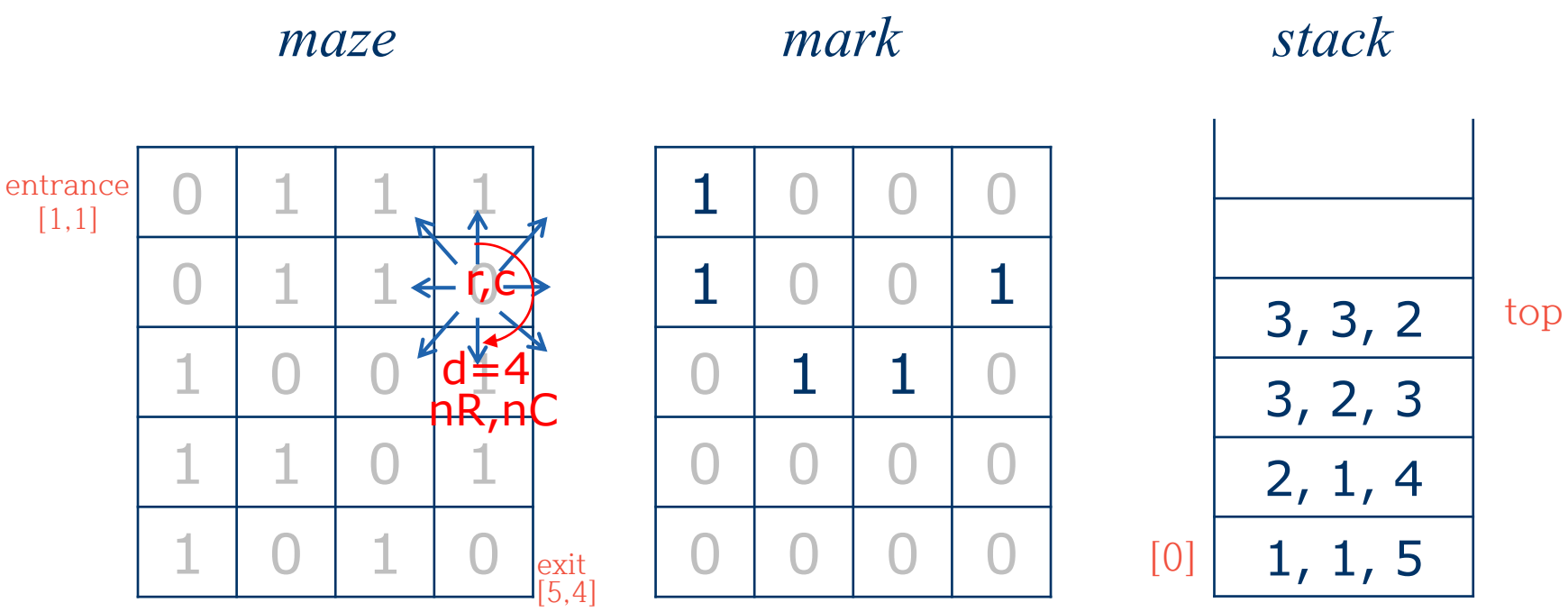
Maze Search : Example



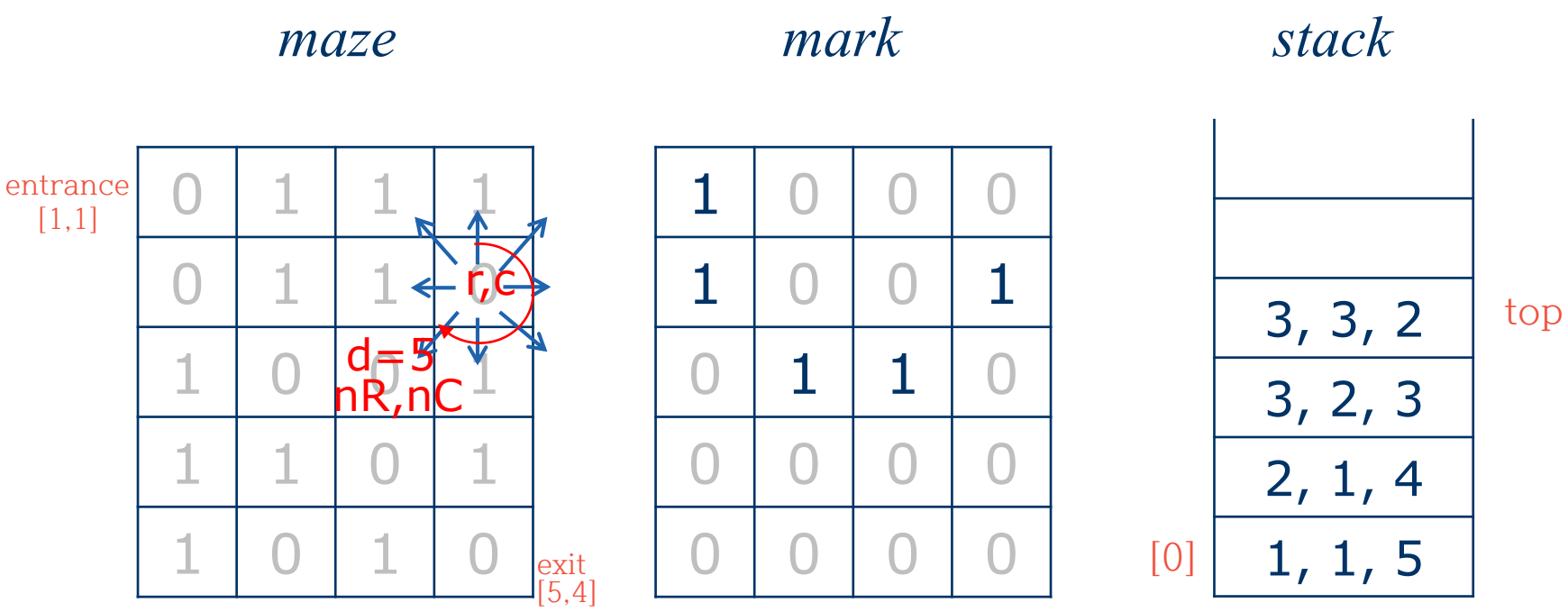
Maze Search : Example



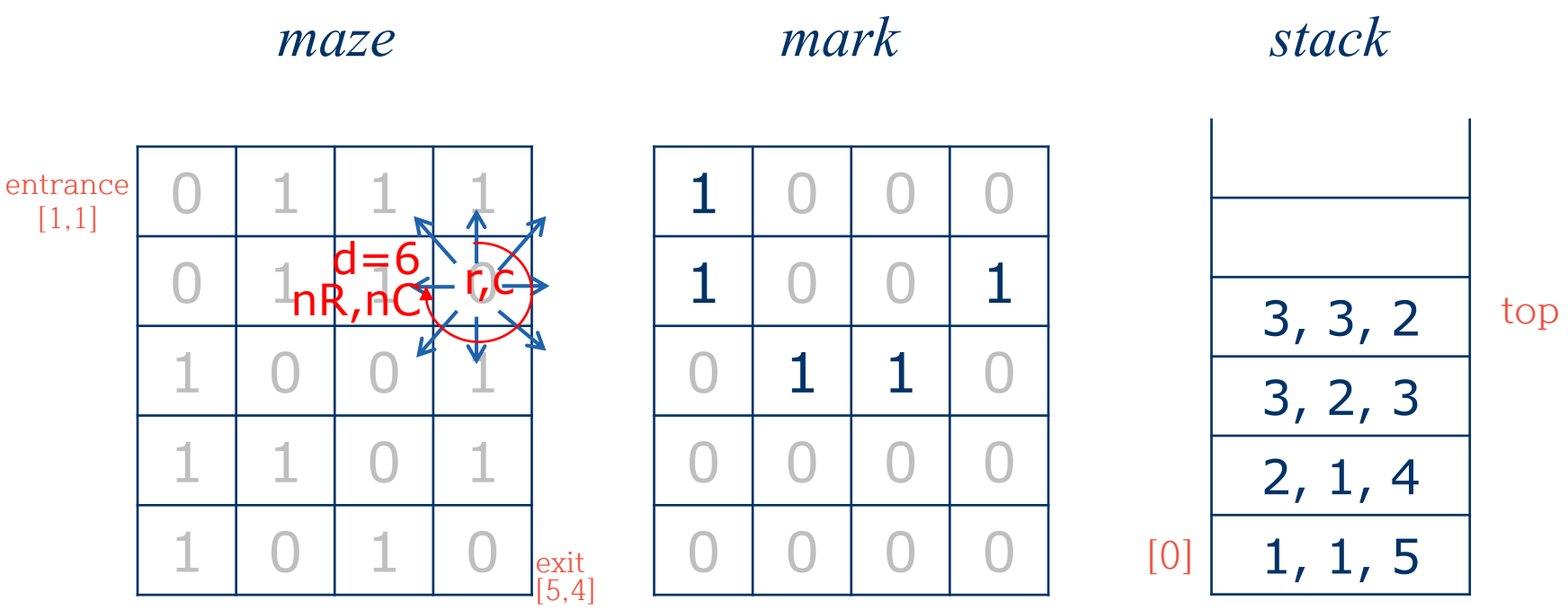
Maze Search : Example



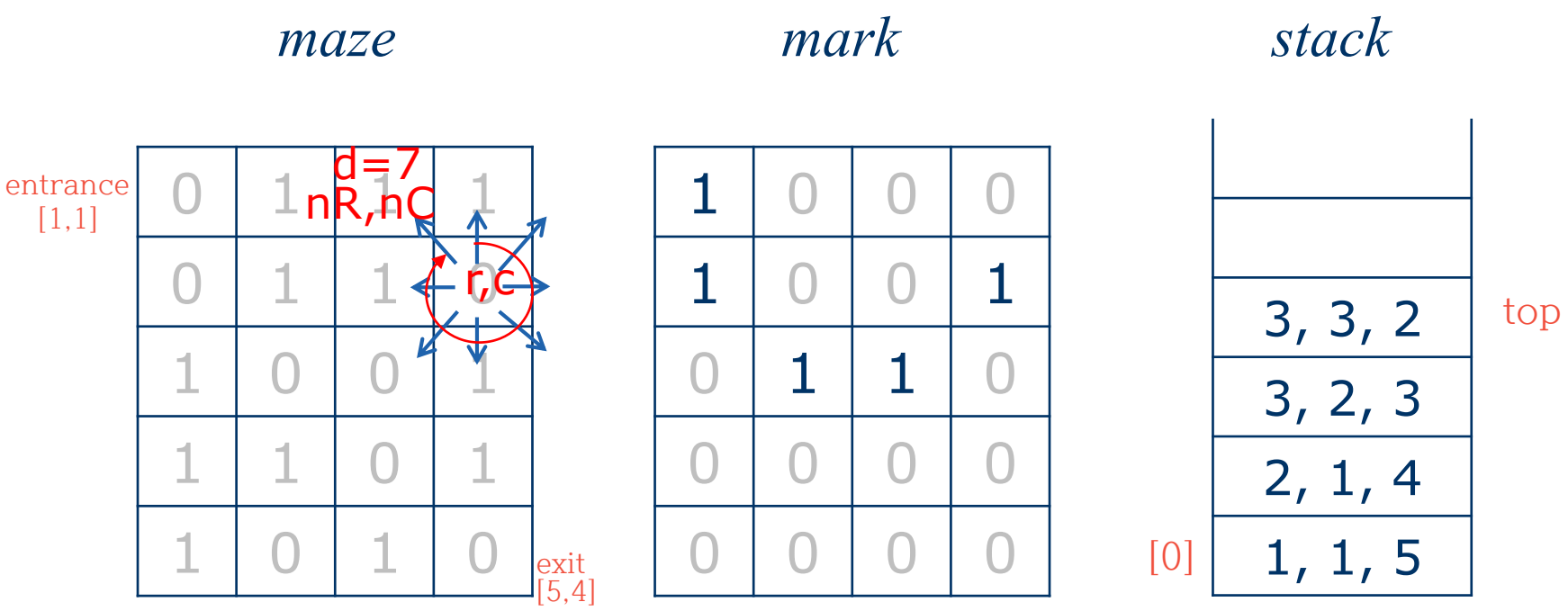
Maze Search : Example



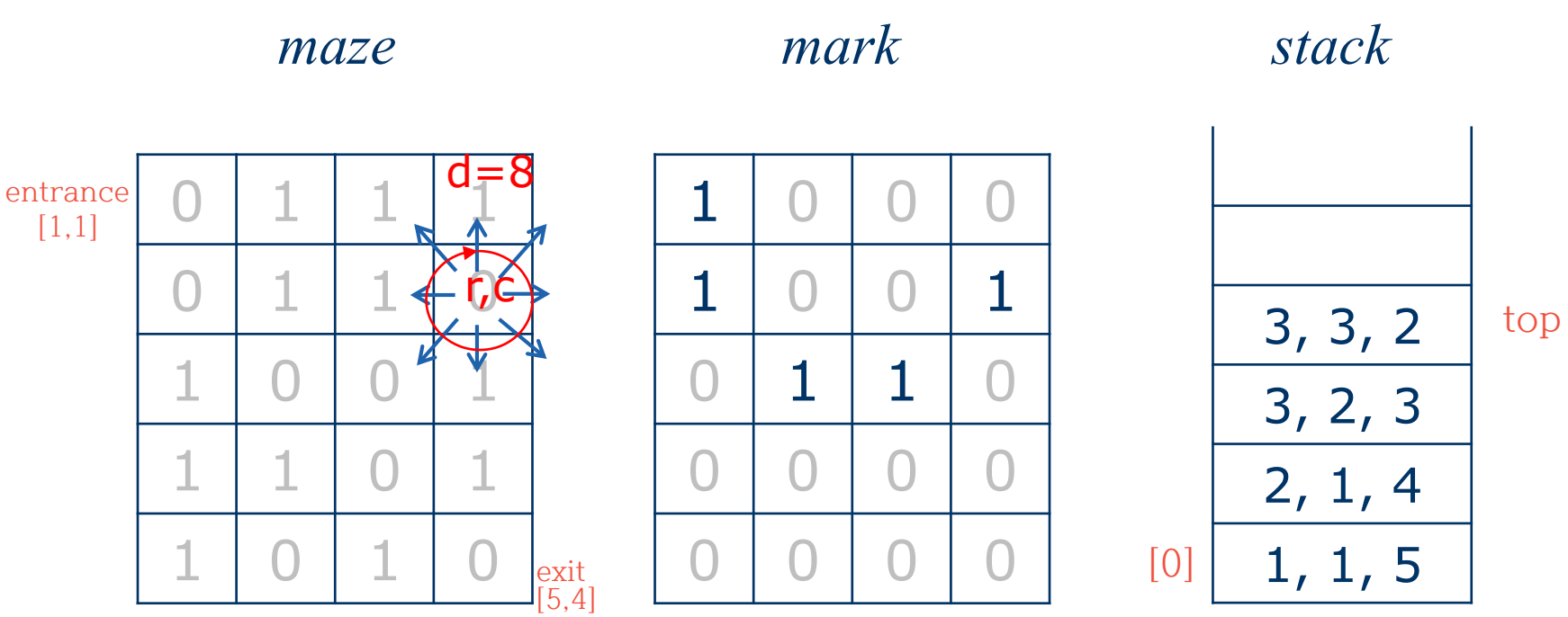
Maze Search : Example



Maze Search : Example

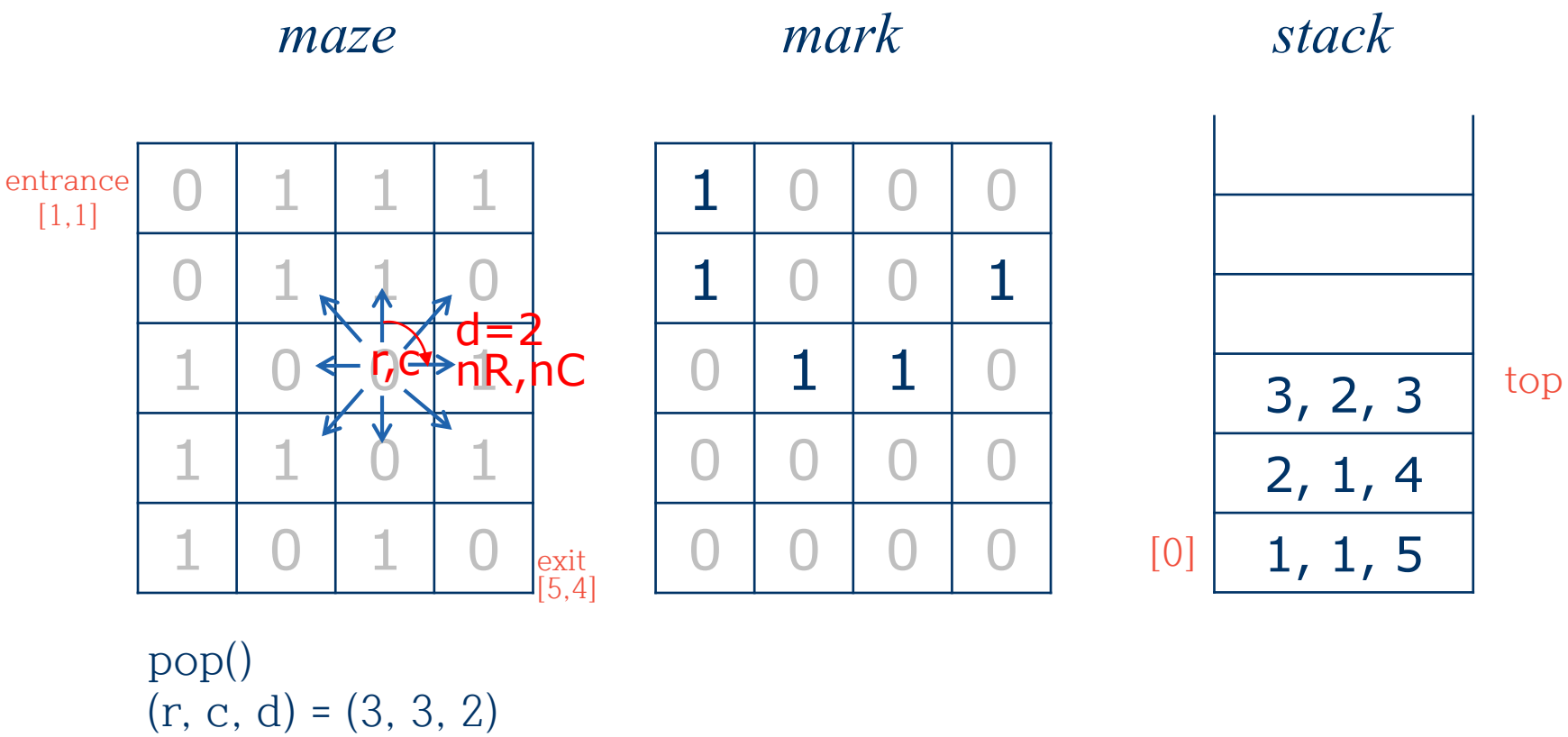


Maze Search : Example



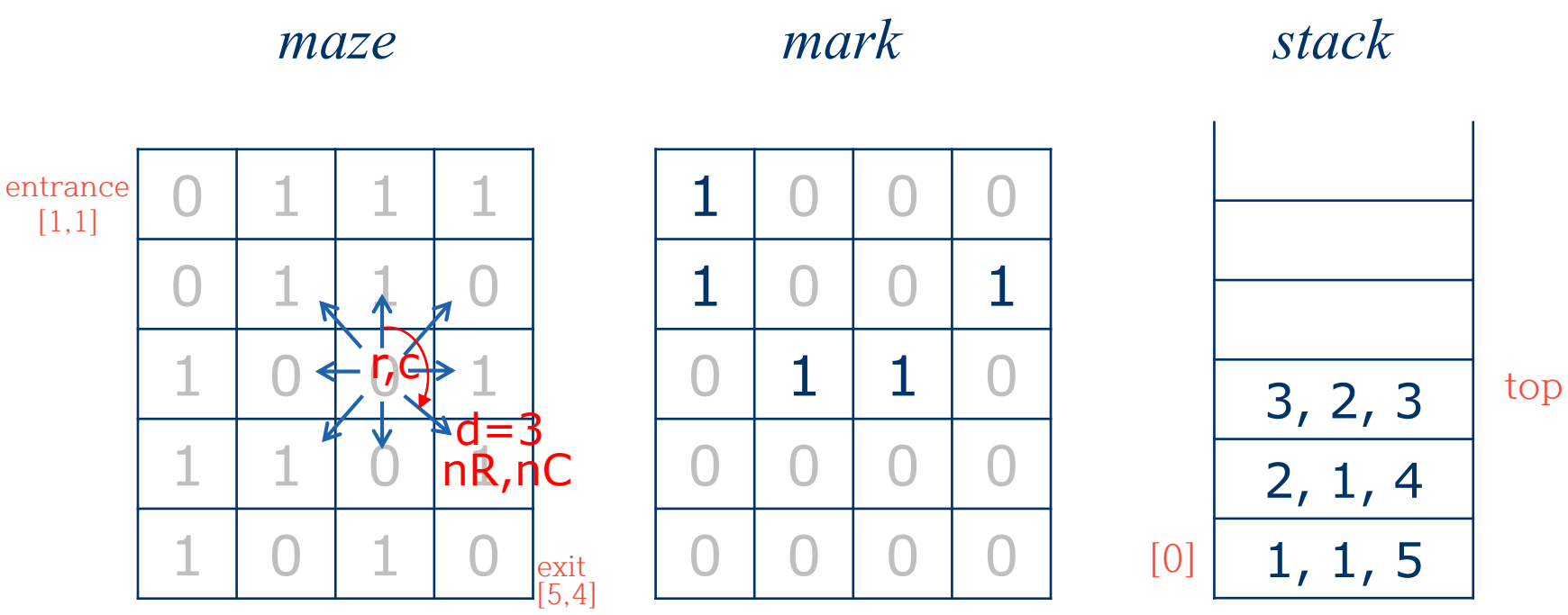
(d < 8 && !found) ? No!
(top > -1 && !found) ? Yes!

Maze Search : Example

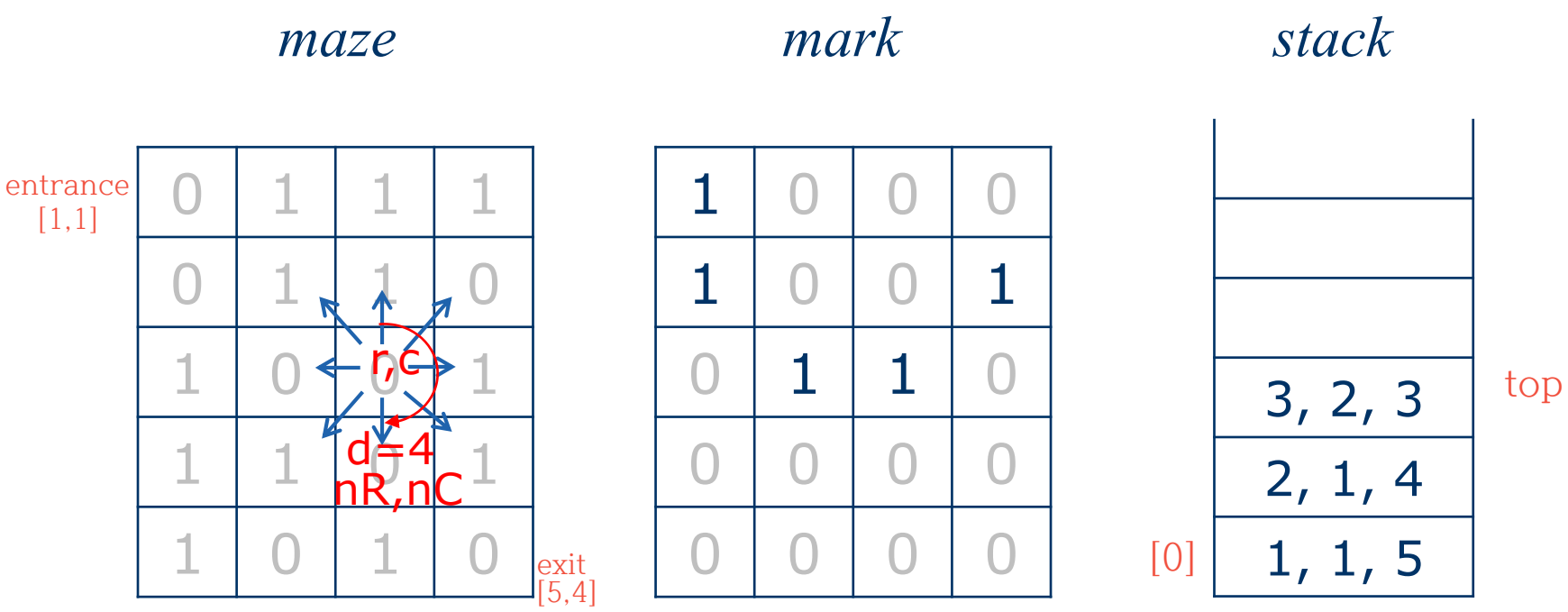


pop()
(r, c, d) = (3, 3, 2)

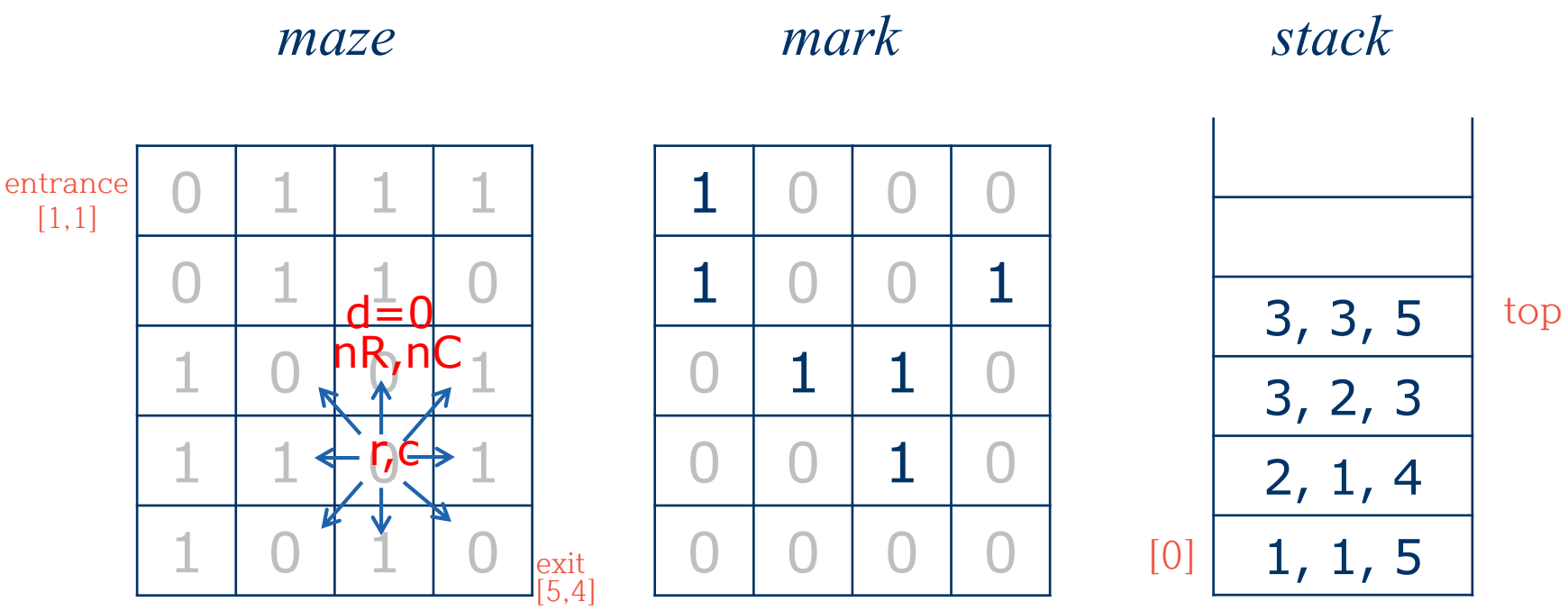
Maze Search : Example



Maze Search : Example

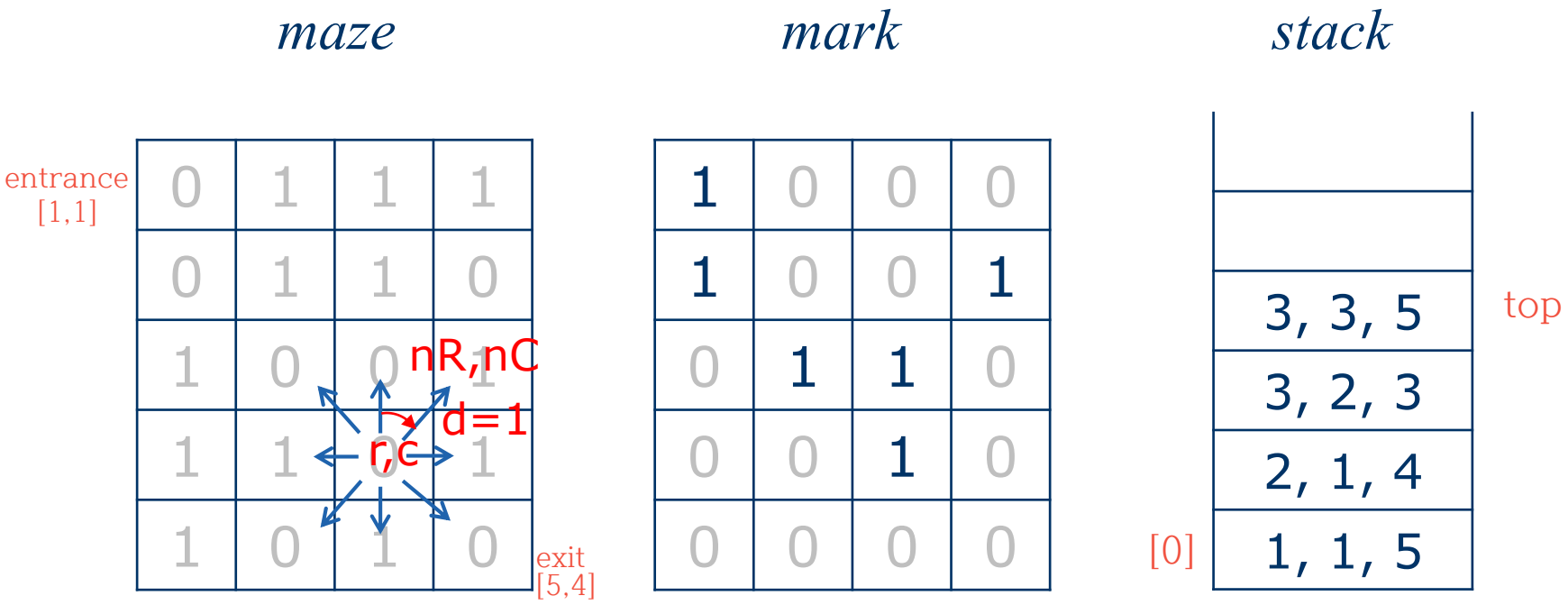


Maze Search : Example

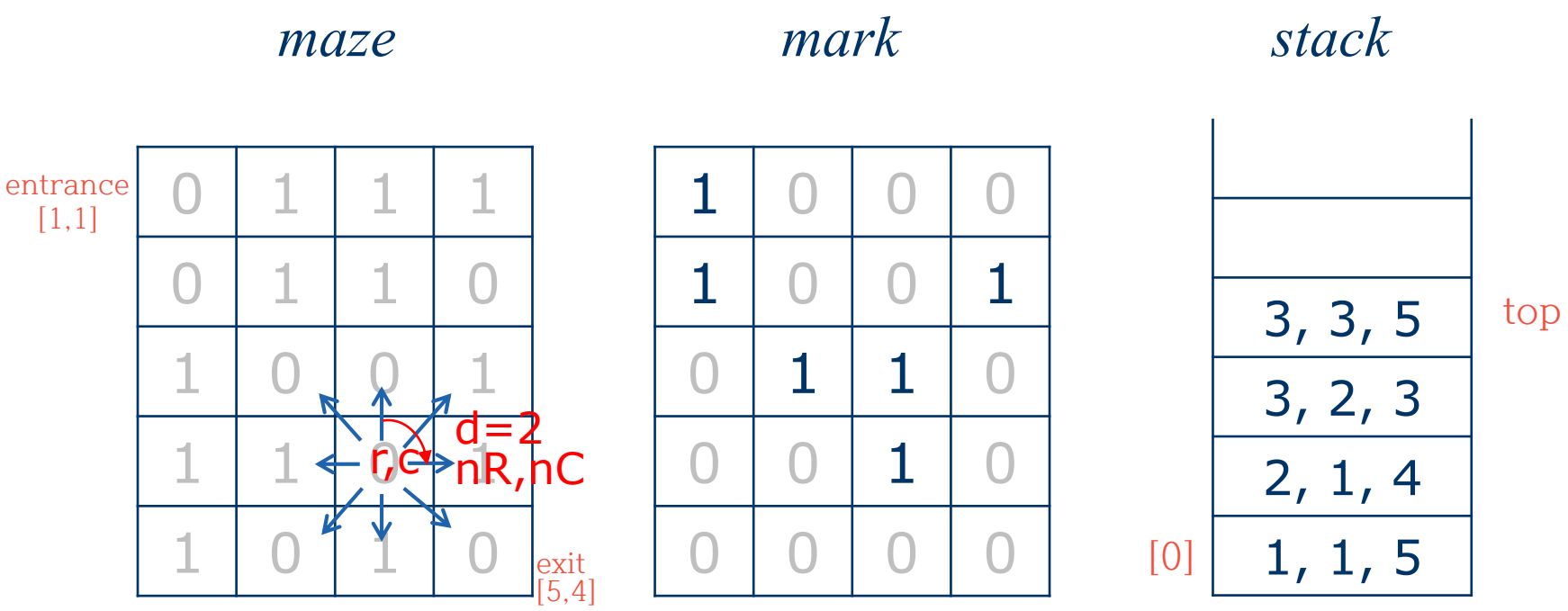


push(3, 3, 5)
(4, 3) 방문, (r, c, d) = (4, 3, 0)

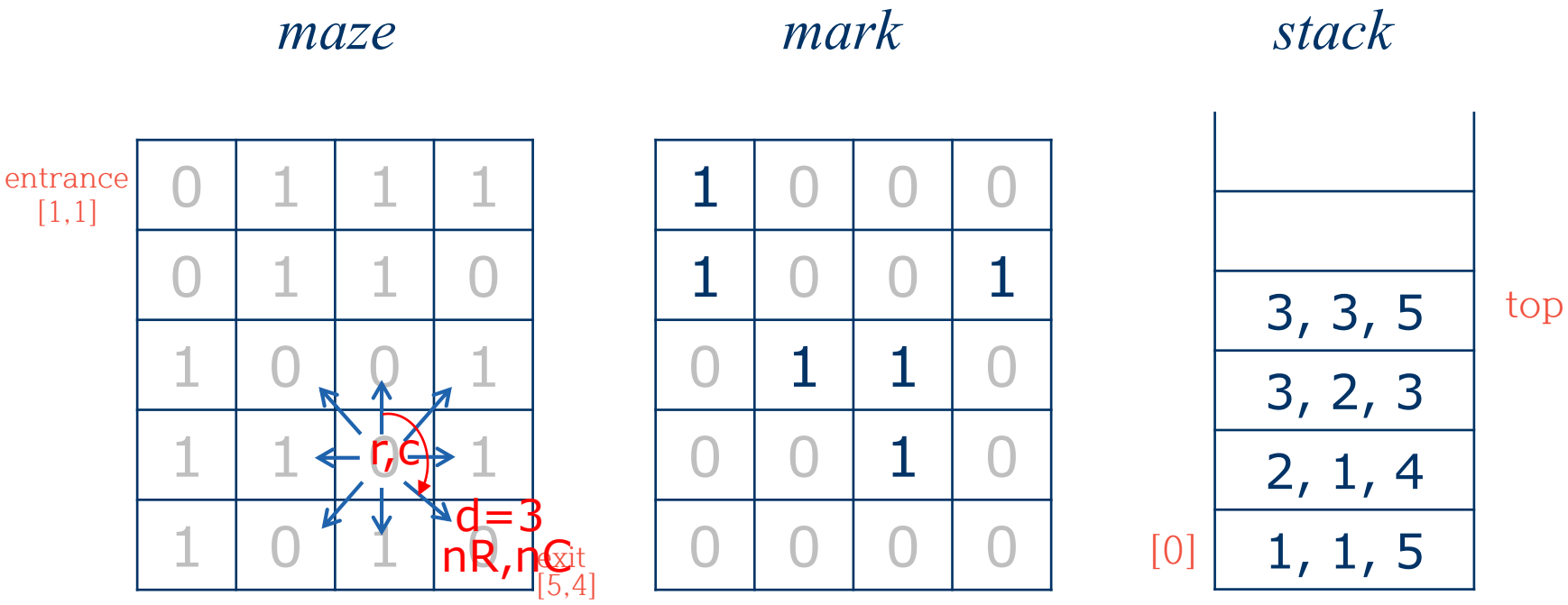
Maze Search : Example



Maze Search : Example

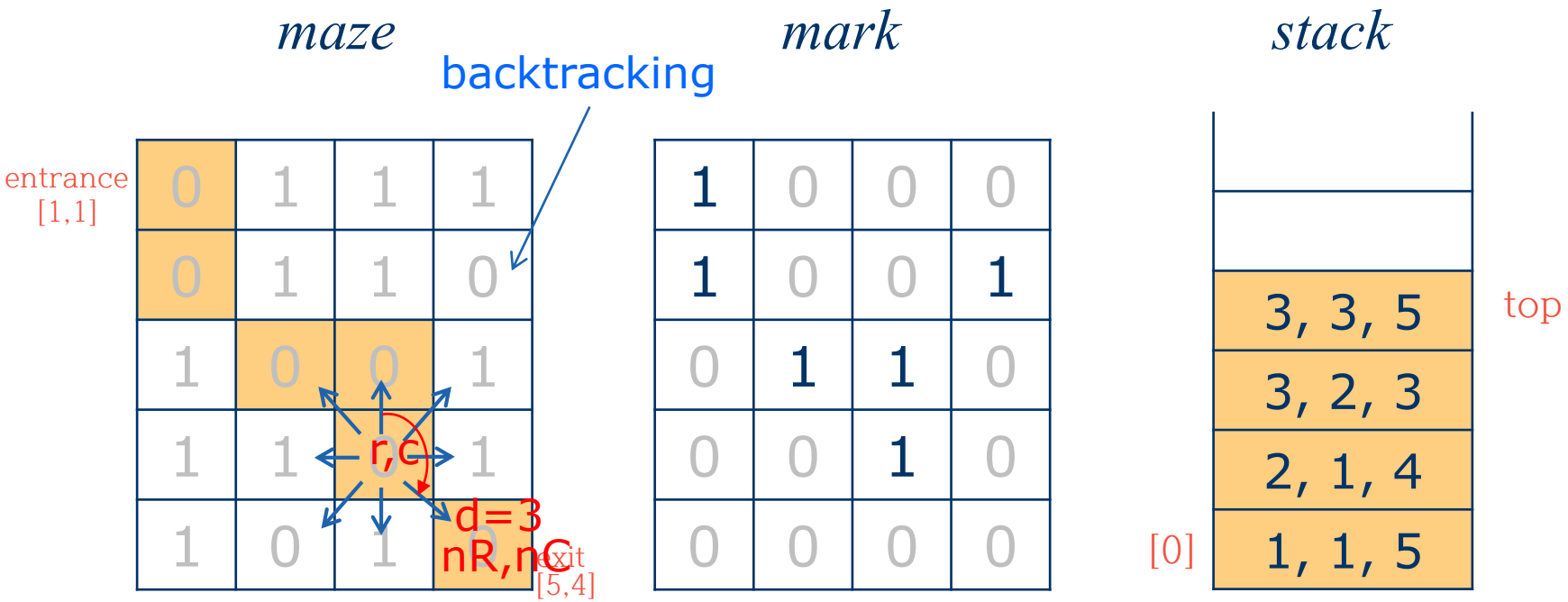


Maze Search : Example



다음 위치 (nR, nC)가 출구(EXIT_ROW, EXIT_COL)임
경로발견!

Maze Search : Example



< 경로출력순서>

① stack[0] → stack[top]
② 현재 위치 (r, c)
③ 출구 위치 (EXIT_ROW, EXIT_COL)
path: (1, 1), (2, 1), (3, 2), (3, 3), (4, 3), (5, 4)

Implementation in C

Stack

- Use the implementation of section 3.1 or 3.2

```
typedef struct {
        short int row;
        short int col;
        short int dir;
        } element;
```

- Capacity
  - Each position in the maze is visited no more than once.
  - An $m \times p$ maze has at most mp zeroes.
  - ***mp*** is sufficient for the stack capacity.

Implementation in C

```
initialize a stack to the maze's entrance coordinates and
direction to north;
while (stack is not empty) {
   /* move to position at top of stack */
   <row,col,dir> = delete from top of stack;
   while (there are more moves from current position) {
      <nextRow, nextCol> = coordinates of next move;
      dir = direction of move;
      if ((nextRow == EXIT_ROW) && (nextCol == EXIT_COL))
         success;
      if (maze[nextRow][nextCol] == 0 &&
                  mark[nextRow][nextCol] == 0) {
      /* legal move and haven't been there */
         mark[nextRow][nextCol] = 1;
         /* save current position and direction */
         add <row,col,dir> to the top of the stack;
         row = nextRow;
         col = nextCol;
         dir = north;
      }
   }
}
printf("No path found\n");
```

Program 3.11: Initial maze algorithm

Implementation in C

```
void path(void)
{/* output a path through the maze if such a path exists */
  int i, row, col, nextRow, nextCol, dir, found = FALSE;
  element position;
  mark[1][1] = 1; top = 0;
  stack[0].row = 1;  stack[0].col = 1;  stack[0].dir = 1;
  while (top > -1 && !found) {
    position = pop();
    row = position.row;  col = position.col;
    dir = position.dir;
    while (dir <  8 && !found) {
      /* move in direction dir */
      nextRow = row + move[dir].vert;
      nextCol = col + move[dir].horiz;
      if (nextRow == EXIT_ROW && nextCol == EXIT_COL)
        found = TRUE;
      else if ( !maze[nextRow][nextCol] &&
      ! mark[nextRow][nextCol]) {
        mark[nextRow][nextCol] = 1;
        position.row = row; position.col = col;
        position.dir = ++dir;
        push(position);
        row = nextRow; col = nextCol; dir = 0;
      }
      else ++dir;
    }
  }
  if (found) {
    printf("The path is:\n");
    printf("row  col\n");
    for (i = 0; i <= top; i++)
      printf("%2d%5d",stack[i].row, stack[i].col);
    printf("%2d%5d\n",row,col);
    printf("%2d%5d\n",EXIT_ROW,EXIT_COL);
  }
  else printf("The maze does not have a path\n");
}
```

Program 3.12: Maze search function

Analysis of *path*:

- each position within the maze is visited no more than once,
- worst case complexity : **O(*mp*)**, for $m \times p$ maze