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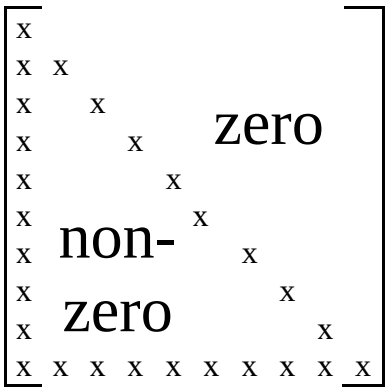
Data Structures Quiz, Chapter 2, Oct. 7, 2024

1. Suppose that an array is declared as *a*[5][4][6], where the address of *a*[0][0][0] is 200 and each element requires four bytes. Calculate the address of element *a*[3][2][3] for the r*ow-major* representation and the *column-major* representation. (30%)

2. (a) Please describe the data structure used for representing a set in the Homework 2. (15%)

   (b) How do you implement the concepts of set union, set intersection and set difference for Homework 2? (15%)

3. A *lower triangular* array *a* is an *n*-by-*n* array in which *a*[*i*][*j*]==0, if *i* < *j*. We need not store the zero elements in the memory. Suppose that the non-zero elements of array *a* are stored in one-dimensional array *b* sequentially with *a*[0][0] being stored in *b*[0], where the upper left corner of the matrix is *a*[0][0]. What is the maximum number of nonzero elements in array *a*? Suppose that the element *a*[*i*][*j*] in the lower triangle is stored in *b*[*k*]. Please calculate the addressing formula for *k* with *i* and *j*. (40%)



參考解答：

1. Row-major: 200 + (3*4*6+2*6+3)*4 = 548 // ch02, p. 2-15

   Column-major: 200 + (3+2*5+3*4*5)*4 = 492 // ch02, p. 2-17

2. 詳見 課程講義 ch02, p.2-18, p. 2-19

3. (a) What is the maximum number of nonzero elements in array *a*?

   如附圖可見，非零所在為 i ≥ j，形成的圖形為一梯形，其數量為

   $$1 + 2 + 3 + \ldots + n$$

   之等差數列，故套用等差公式得：$\frac{n(n+1)}{2}$

   (b) 轉換後，[i][j]相對應的 b[*k*] 之 *k* 值如下圖，

   (0, 0) : $k = 0$ ；(1, 0): $k = 1$ ； (1, 1): $k = 2$ ….

   ```
   [ 0
     1  2
     3  4  5
     6  7  8  9
    10 11 12 13 14
    15 16 17 18 19 20
    21              . . .                ]
   ```

   經過觀察可以發現，相對應的 *k* 等於該 row 上方的總數+ j :

   $$(1 + 2 + \cdots + i) + j = \frac{i * (i + 1)}{2} + j$$

   例如

   ```
   0
   1  2
   3  4  5
   ```

   可以發現第 i=2 列{3, 4, 5} = 上方總數 + k = 3 + {0, 1, 2}，又因為 index 從 0 開始，故第 2 列上方總數以 i=2 進行計算。