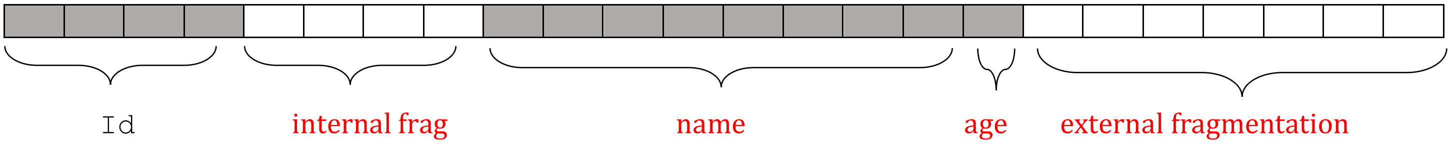
# CSE 351 Section 5 Solutions – Arrays and Structs

Welcome back to section, we're happy that you're here ☺

```
struct Student {
  int id;
  char* name;
  char age;
};
```

a) Fill in which bytes are used by which variables and label the rest as internal or external fragmentation. The first variable "id" is given.



b) What is the size of `struct Student`? **24 bytes**

c) Give a reordering of the fields in `struct Student` such that there is no internal fragmentation

```
struct Student {
     char* name;
     int id;
     char age;
};
```

d) How much external fragmentation does this new `struct Student` have? **3 bytes**

e) What is the size of this new `struct Student`? **16 bytes** (smaller than before)

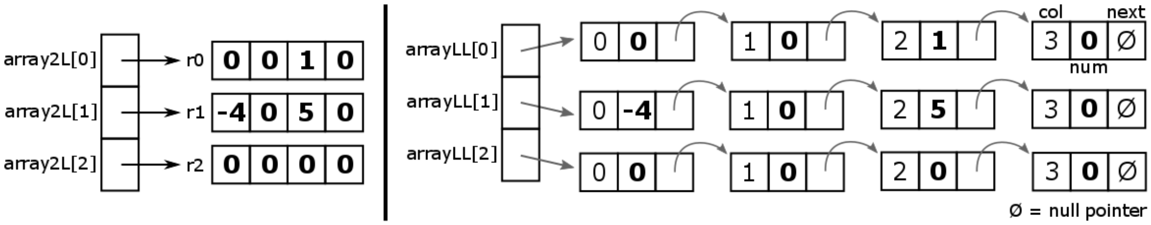
We have a two-dimensional matrix of integer data of size $M$ rows and $N$ columns. We are considering 3 different representation schemes:

1) 2-dimensional array **int** `array2D[][]`, // M*N array of ints
2) 2-level array **int*** `array2L[]`, and // M array of int arrays
3) array of linked lists **struct node*** `arrayLL[]`. // M array of linked lists (struct node)

Consider the case where $M = 3$ and $N = 4$. The declarations are given below:

| **2-dimensional array:** | **2-level array:** | **Array of linked lists:** |
|---|---|---|
| `int array2D[3][4];` | `int r0[4], r1[4], r2[4];`<br>`int* array2L[] = {r0,r1,r2};` | `struct node {`<br>`        int col, num;`<br>`        struct node* next;`<br>`};`<br>`struct node* arrayLL[3];`<br>`// code to build out LLs` |

For example, the diagrams below correspond to the matrix $\begin{bmatrix}0&0&1&0\\-4&0&5&0\\0&0&0&0\end{bmatrix}$ for `array2L` and `arrayLL`:



a) Fill in the following comparison chart:

| | 2-dim array | 2-level array | Array of LLs: |
|---|---|---|---|
| Overall Memory Used | M*N*sizeof(int) = 48 B | M*N*sizeof(int) + M*sizeof(int *) = 72 B | M*sizeof(struct node *) + M*N*sizeof(struct node) = 216 B |
| Largest *guaranteed* continuous chunk of memory | The whole array (48 B) | The array of pointers (24 B) > row array (16 B) | The array of pointers (24 B) > struct (16 B) |
| Smallest *guaranteed* continuous chunk of memory | The whole array (48 B) | Each row array (16 B) | Each struct node (16 B) |
| Data type returned by: | `array2D[1]`<br>`int *` | `array2L[1]`<br>`int *` | `arrayLL[1]`<br>`struct node *` |
| Number of memory accesses to get `int` in the *BEST* case | 1 | 2 | First node in LL: 2 |
| Number of memory accesses to get `int` in the *WORST* case | 1 | 2 | Last node in LL: 5<br>(we have to read `next`) |

b) Sam Student claims that since our arrays are relatively small ($N < 256$), we can save space by storing the `col` field as a **char** in **`struct node`**. Is this correct? If so, how much space do we save? If not, is this an example of internal or external fragmentation?

No. Alignment requirement of $K = 4$ for **`int`** `num` leaves 3 bytes of internal fragmentation between `col` and `num`.

c) Provide a scenario where a 2-dimensional array would be more useful and another where a 2-level array would be more useful.

- 2D Array - Creating a table or a matrix where all rows are the same size. This way memory accesses are reduced and less memory is required.

- 2-Level Array - When creating a list where different index sizes differ or sub-arrays are subject to replacement. In other words, when the array is more flexible to changes.

d) Sam wants to create a 2-D matrix of the countries of the world that can be accessed alphabetically. Which implementation should Sam choose to represent this information? Describe what this implementation would look like.

$$\begin{bmatrix} Afghanistan & Albania & \dots & Azerbaijan \\ Bahamas & \dots & Burundi & - - - \\ \vdots & \vdots & \vdots & \vdots \\ Zambia & Zimbabwe & - - - & - - - \end{bmatrix}$$

Sam should use a 2-level array since the amount of countries starting with a given letter will vary (i.e. there are more countries that start with A than Q). He could make an array of pointers from 0 to 25 which would point to custom-sized arrays of country names starting with each corresponding letter of the alphabet.