Introduction to Lab #3: Lab_CubeStats

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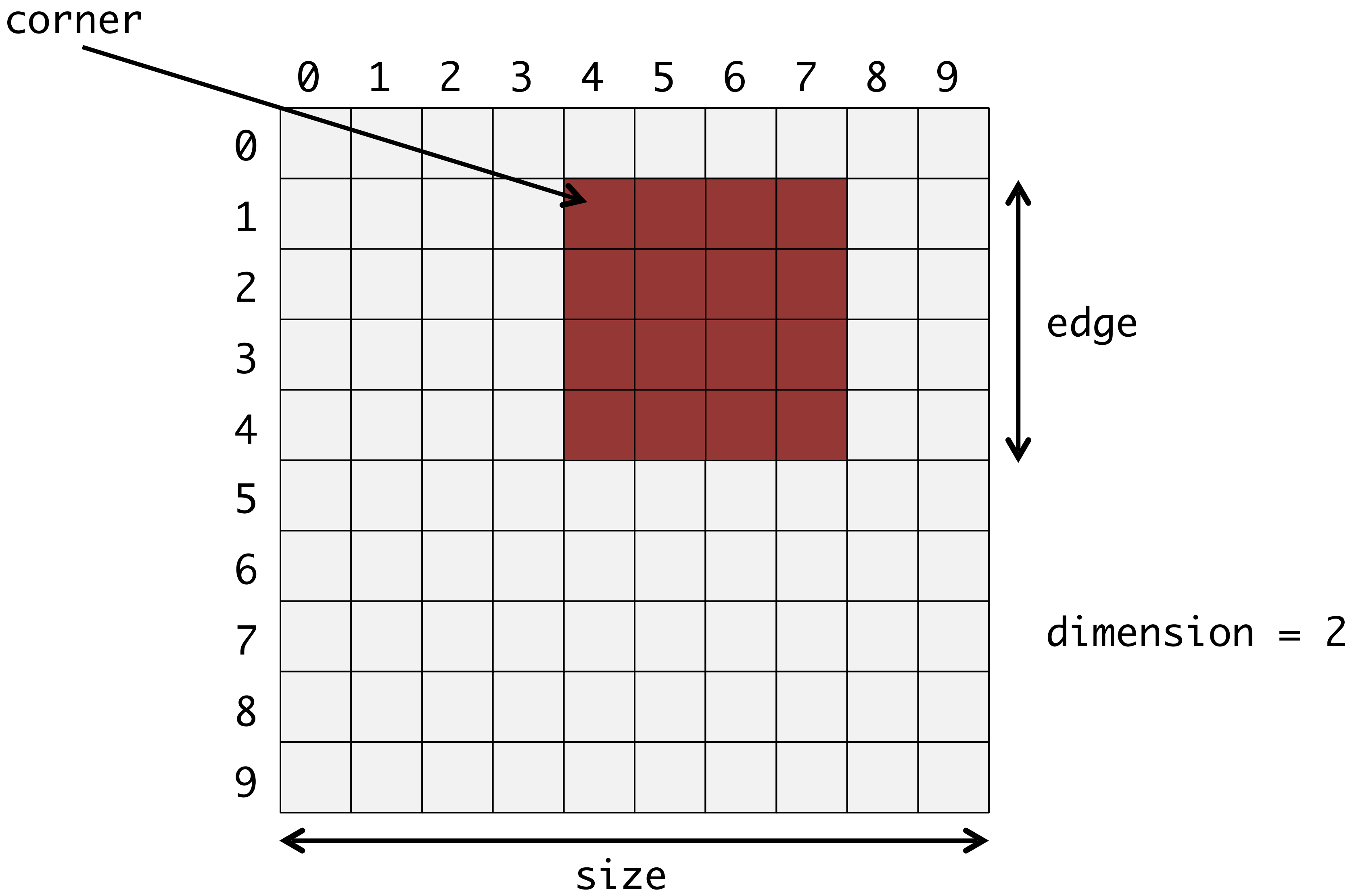
Requirements

- Follow all subroutine calling conventions
- Must use $fp to access anything that is stored in the stack
  - Only can use $sp in this assignment to change the size of the stack.

`CubeStats`

- Receives the following parameters:
  - `corner`: the address of the first element of a cube in an *n*-dimensional array.
  - `edge`: the size of the edge of the cube.
  - `dimensions`: the number of dimensions of the cube (and base array).
  - `size`: the size of the base array
    - Assume that the size of the base array is the same in all dimensions, *i.e.* the base array is itself a cube

A two-dimensional example



corner

edge

dimension = 2

size

CubeStats Return Values

- `$v0`: a signed integer representing the floor of the average of all negative elements in the specified cube.

- `$v1`: a signed integer representing the floor of the average of all positive elements in the specified cube.

CubeStats Return Values --- more formally

CubeStats Return Values --- more formally

$$
\begin{aligned}
C &= \text{Set of elements that are in the specified cube} \\
N &= \{x_i | x_i \in C \wedge x_i < 0\} \\
P &= \{x_i | x_i \in C \wedge x_i > 0\} \\
\$\text{v0} &= \left\lfloor \frac{\sum_{x_i \in N} x_i}{|N|} \right\rfloor \\
\$\text{v1} &= \left\lfloor \frac{\sum_{x_i \in P} x_i}{|P|} \right\rfloor
\end{aligned}
$$

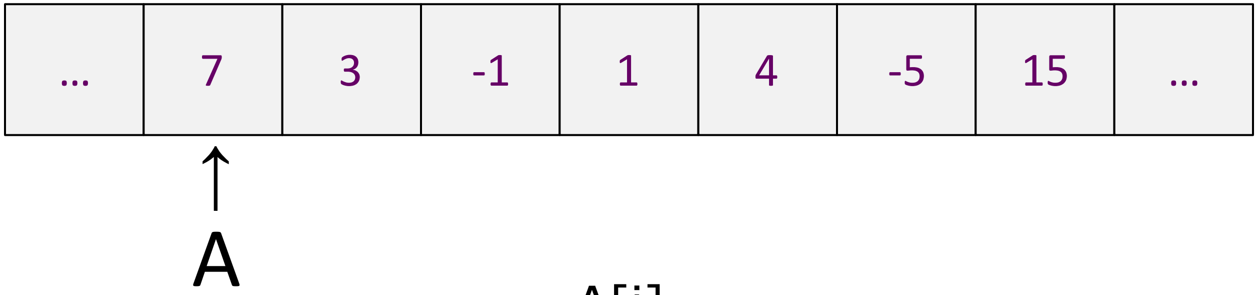
CubeStats (cont.)

- Assume that the parameters are correct:
  - Parameters are positive
  - The Cube is contained within the base array

1-d Array Storage

What is the address of element -1 (i=2) ?

$$A + \quad \times 4$$



A[i]

One-dimensional matrix A.

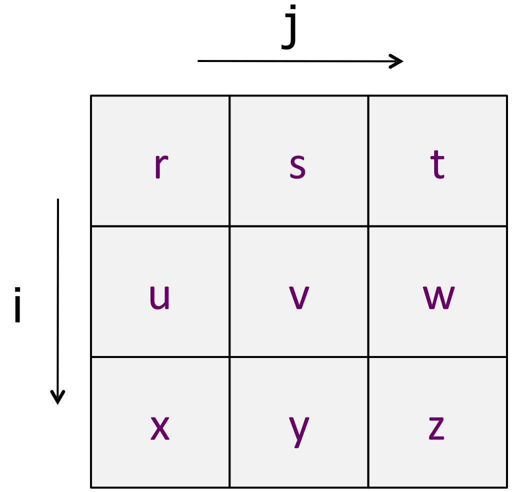
Address	Value
0x10001024	
0x10001020	
0x1000101C	. . .
0x10001018	15
0x10001014	-5
0x10001010	4
0x1000100C	1
0x10001008	-1
0x10001004	3
0x10001000	7
0x10000FFC	. . .

Organization of B in memory in row-major style.

2-d Array Storage

What is the address of element w (i=1, j =2) ?

$$B + (\qquad\qquad\qquad) \times 4$$



r	s	t
u	v	w
x	y	z

B[i][j]

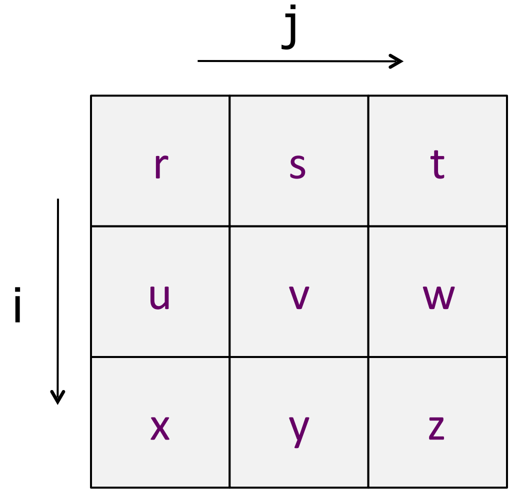
Two-dimensional 3×3 matrix B.

Address	Value
0x10001024	
0x10001020	z
0x1000101C	y
0x10001018	x
0x10001014	w
0x10001010	v
0x1000100C	u
0x10001008	t
0x10001004	s
0x10001000	r
0x10000FFC	

Organization of B in memory
in row-major style.

2-d Array Storage

Which elements belong to a Cube at position (1,1) with an edge = 2?



r	s	t
u	v	w
x	y	z

B[i][j]

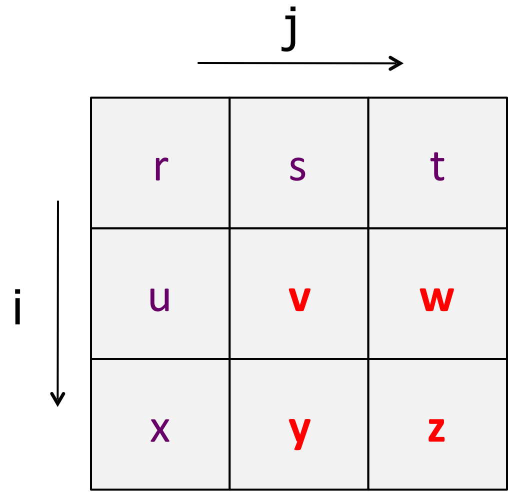
Two-dimensional 3×3 matrix B.

Address	Value
0x10001024	
0x10001020	z
0x1000101C	y
0x10001018	x
0x10001014	w
0x10001010	v
0x1000100C	u
0x10001008	t
0x10001004	s
0x10001000	r
0x10000FFC	

Organization of B in memory in row-major style.

2-d Array Storage

Which elements belong to a Cube at position (1,1) with an edge = 2?



r	s	t
u	**v**	**w**
x	**y**	**z**

B[i][j]

Two-dimensional 3×3 matrix B.

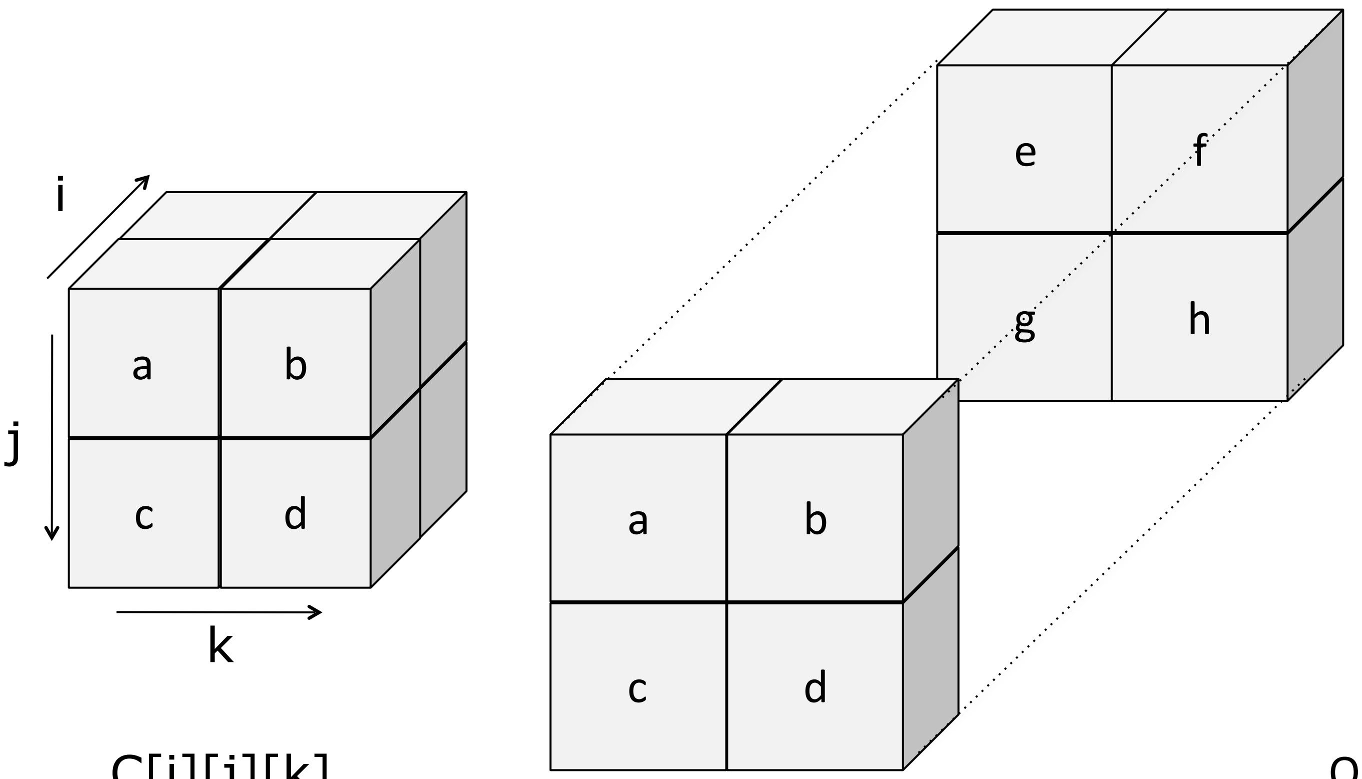
Address	Value
0x10001024	
0x10001020	**z**
0x1000101C	**y**
0x10001018	x
0x10001014	**w**
0x10001010	**v**
0x1000100C	u
0x10001008	t
0x10001004	s
0x10001000	r
0x10000FFC	

Organization of B in memory in row-major style.

3-d Array Storage

What is the address of element h (i=1, j =1, k=1) ?

$$C + (\qquad\qquad\qquad\qquad) \times 4$$



C[i][j][k]

Three-dimensional 2×2×2 matrix C.

Address	Value
0x10001024	
0x10001020	
0x1000101C	h
0x10001018	g
0x10001014	f
0x10001010	e
0x1000100C	d
0x10001008	c
0x10001004	b
0x10001000	a
0x10000FFC	

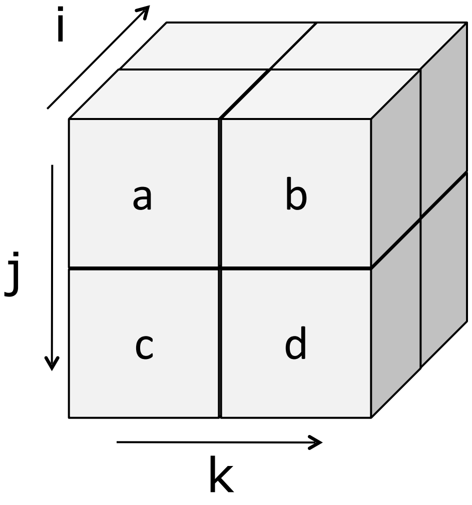
Organization of C in memory in row-major style.

3-d Array Storage

What is the address of element h (i=1, j =1, k=1) ?

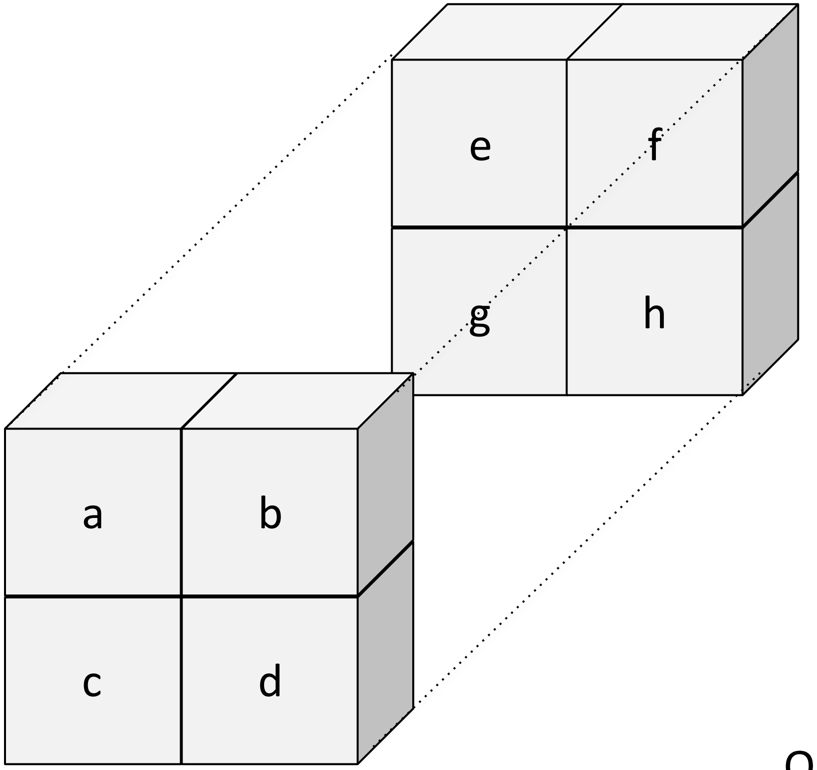
$$C + (((i \times 2) + j) \times 2 + k) \times 4$$

$$C + (i \times 2 \times 2 + j \times 2 + k) \times 4$$



C[i][j][k]

Three-dimensional 2×2×2 matrix C.



Address	Value
0x10001024	
0x10001020	
0x1000101C	h
0x10001018	g
0x10001014	f
0x10001010	e
0x1000100C	d
0x10001008	c
0x10001004	b
0x10001000	a
0x10000FFC	

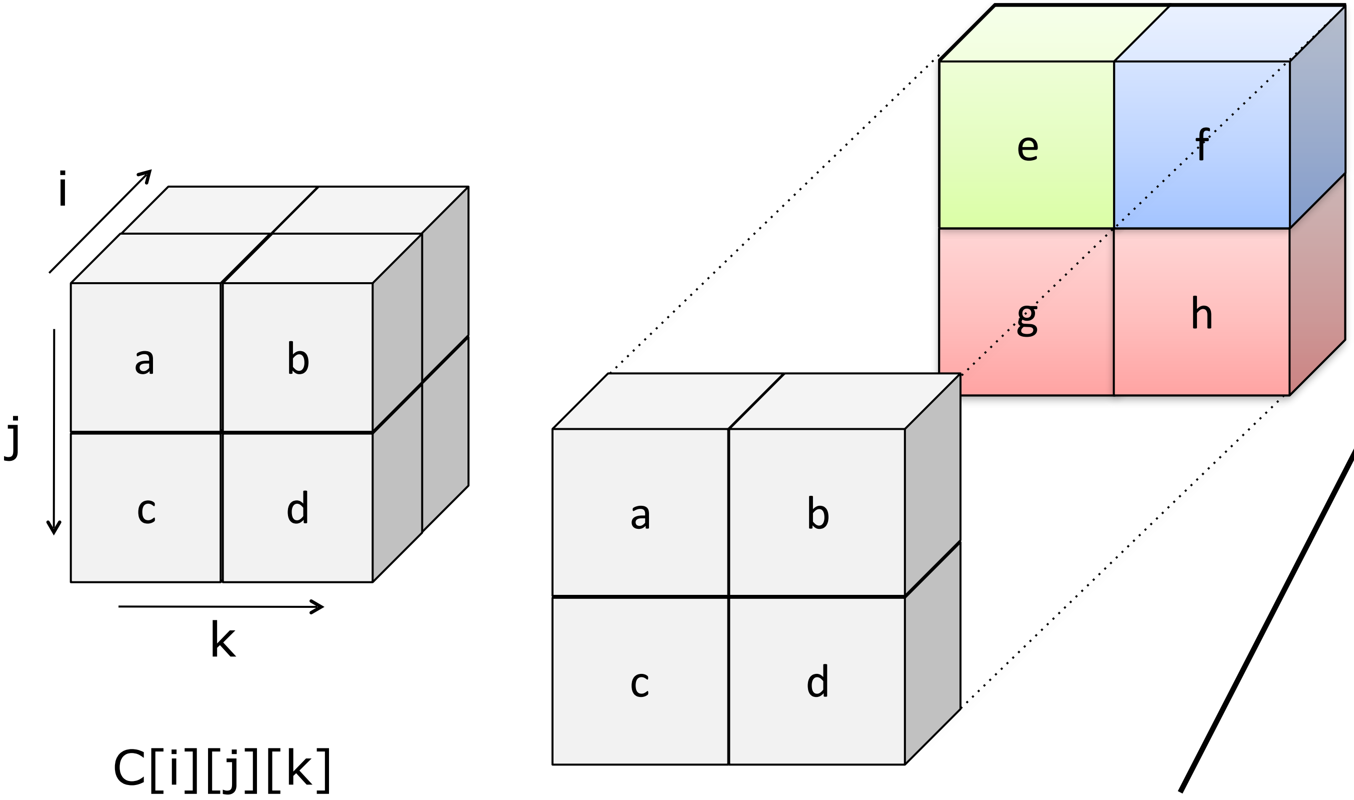
Organization of C in memory in row-major style.

main program

- reads a k-dimensional Cube from a file
- places the values in the memory in row-major format
- for each specification of a cube in the file:
    - initializes four global variables to zero:
        - `totalNeg`, `totalPos`, `countNeg` and `countPos`
    - calls your `CubeStats` subroutine
    - prints the value returned by `CubeStats`

File format

C[1][0][1] ↔ f



dimension of array

size of array

```
3 2
a b
c d
e f
g h
1 0 1 1
0 0 0 2
-1
```

Cube a position (0,0,0) with edge 2

Cube at position (1,0,1) with edge 1

main

- Reading and understanding the main routine is part of the assignment.

Test Generator

- A test generator, written in Python, is provided to you as a convenience.
  - Have fun modifying/playing with it.
- Caution:
  - Large test cases overflow the arena provided
  - Increasing the arena is ok but will eventually run into the static space limit of SPIM.

What to hand in

- A single file named `CubeStats.s` containing your subroutine `CubeStats` written in MIPS assembly.
- Your subroutine must return to the caller using the instruction:

```
    jr $ra
```

- Your file must not contain a main function.
- Don't forget to add **commented** license text!