MSR format in a nutshell.

Fast Iterative Solvers / Summer Semester 2025

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The **Modified Compressed Sparse Row (MSR)** format is a compact way of storing sparse matrices, which are matrices where most of the elements are zero. The MSR format reduces memory usage and improves performance in matrix-vector operations.

Table 1: Example matrix

	n	
	4	10
1	6	12.0
2	8	4.0
3	8	2.0
4	8	14.0
5	11	0.0
6	2	-5.0
7	4	3.0
8	1	5.0
9	2	-2.0
10	3	-3.0

- The first line of the text indicates the symmetry of the matrix: **n** for non-symmetric, and **s** for symmetric.
- The second line indicates the size of the matrix (n), and the total number of entries of the MSR format (nnz), which considers diagonal values, free marker, and off-diagonal values.
  Then, for Table 1, is a non-symmetric matrix, size 4x4, with a total of 10 entries.

Next, the MSR matrix is stored in two arrays:

- val (or A) – stores:
  - The diagonal elements of the matrix first (size = n) [0 : n]
  - The intermediate value is set to (0) as a marker. (n+1 position)
  - Then the nonzero off-diagonal elements are row-wise. [n+2 : nnz]

- bindx (or col_ind) – stores:
  - First element: index in val where off-diagonal values start (usually n+2), could be taken as row indicator. E.g., for the presented matrix, the first row starts at bindx row 6, then the second row starts at bindx 8. Then, bindx 6, 7 correspond to the

first row, i.e., (1,2) = -5.0 and (1,4) = 3.0. (considering the corresponding column and its value).

- The number of off-diagonal columns to consider for that row is calculated by subtracting the bindx values for the [0: n+1] elements of the bindx vector. It could be considered as:

$$columns\ per\ row[i] = bindx(i+1) - bindx(i)$$

Thus, following this, for the matrix presented in Table 1, the rows will have:

Row 1: 8 – 6 = 2 off-diagonal columns
Row 2: 8 – 8 = 0 off-diagonal columns
Row 3: 8 – 8 = 0 off-diagonal columns
Row 4: 11 – 8 = 3 off-diagonal columns

Just as shown in Figure 1.

- Next, the column indices of each off-diagonal value are shown starting from n+2. [n+2 : nnz]

In Figure 1, it is possible to observe the matrix already decompressed from the MSR format. I hope this short guide helps you to decompress MSR format matrices ☺

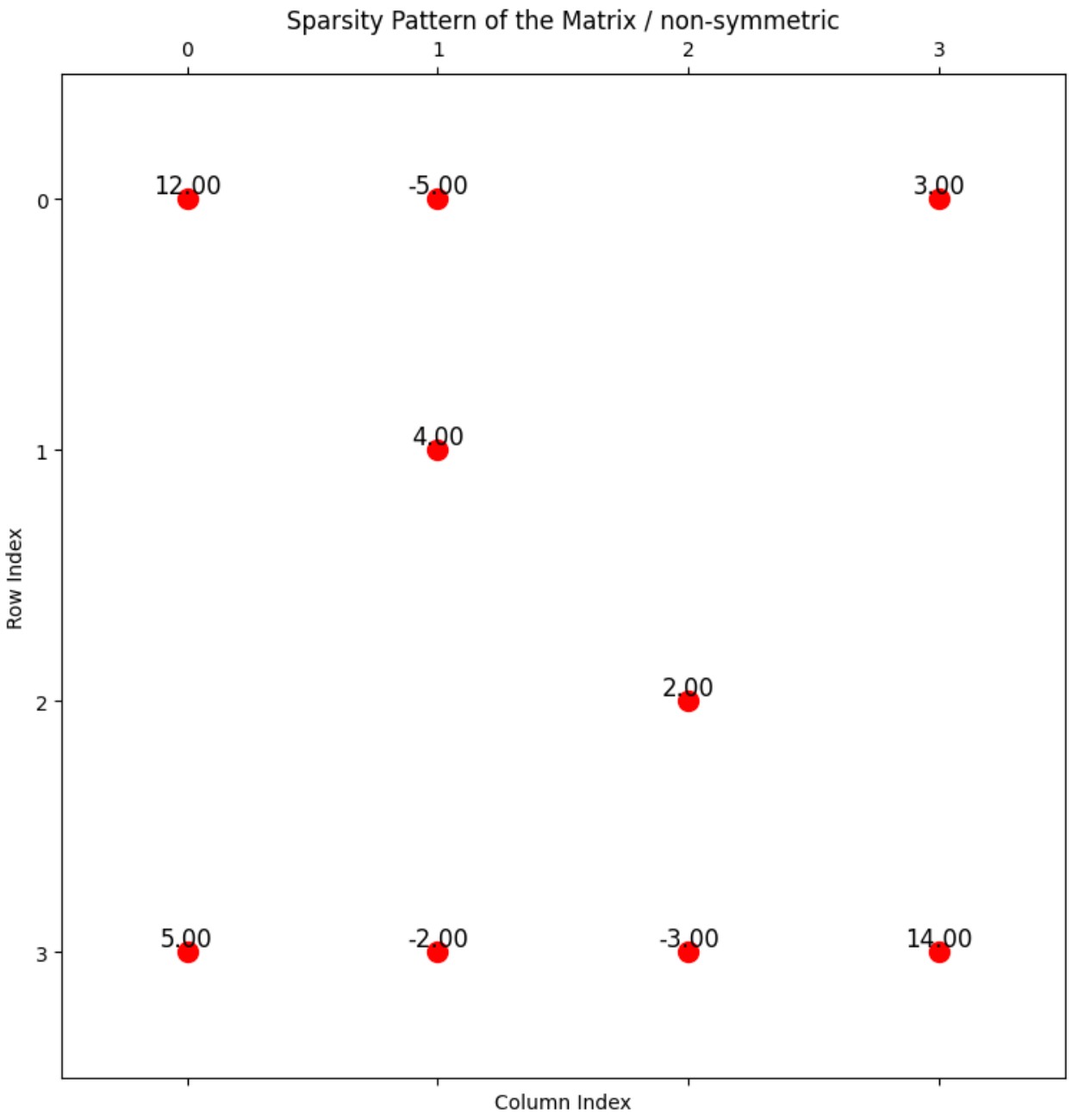
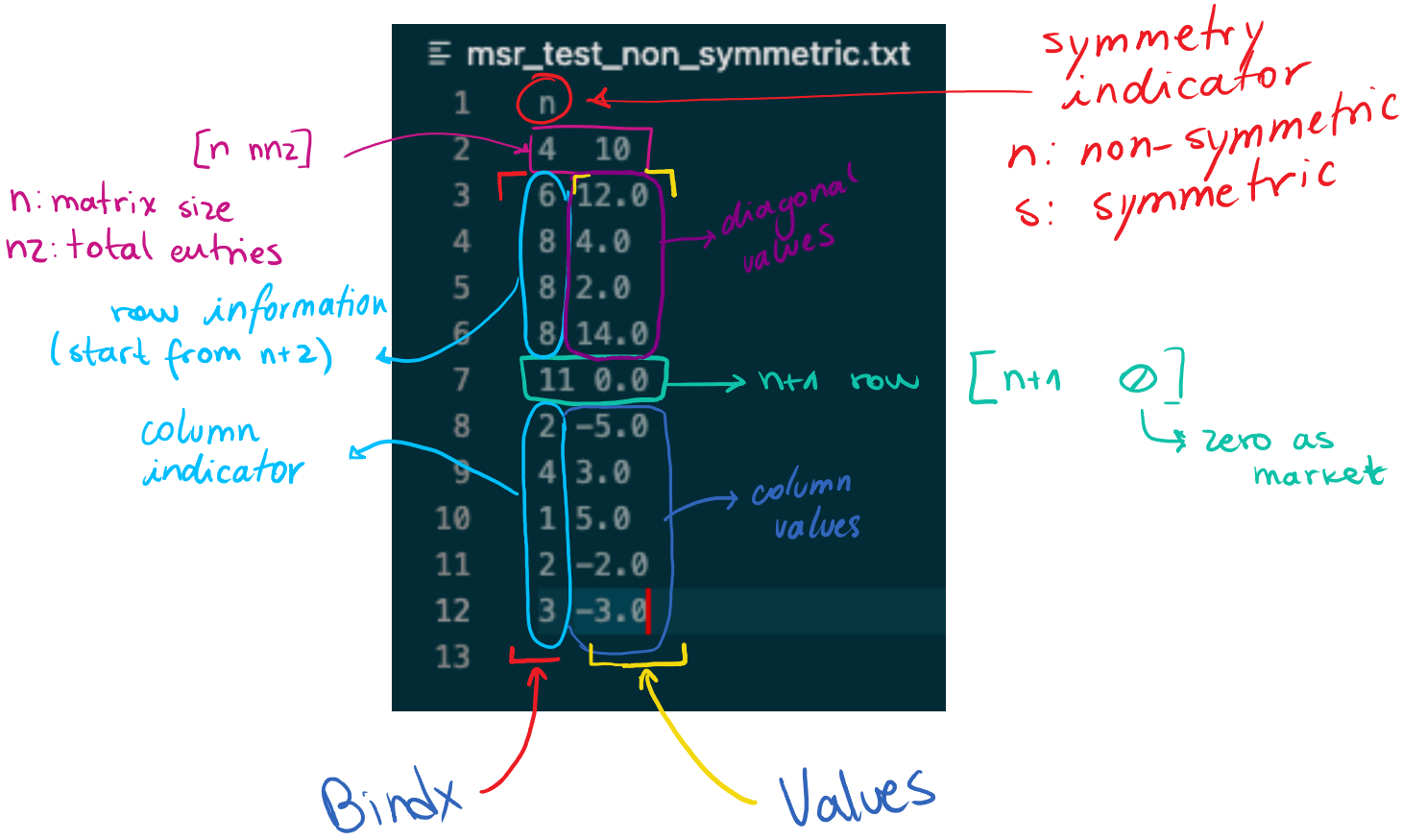


Figure 1: Matrix sparsity pattern.


msr_test_non_symmetric.txt
1 n
2 4 10
3 6 12.0
4 8 4.0
5 8 2.0
6 8 14.0
7 11 0.0
8 2 -5.0
9 4 3.0
10 1 5.0
11 2 -2.0
12 3 -3.0
13
symmetry indicator
n: non-symmetric
s: symmetric
[n nnz]
n: matrix size
nz: total entries
row information
(start from n+2)
diagonal values
n+1 row
[n+1 ∅]
zero as marker
column indicator
column values
Bindx
Values