# frovedis::ccs\_matrix<T,I,O>

# **NAME**

frovedis::ccs\_matrix<T,I,O> - A two-dimensional row-wise distributed sparse matrix with compressed column storage.

# **SYNOPSIS**

```
#include <frovedis/matrix/ccs_matrix.hpp>
```

#### Constructors

```
ccs_matrix ();
ccs_matrix (const crs_matrix<T,I,0>& m);
```

## **Public Member Functions**

```
void debug_print ();
```

## **Public Data Members**

```
frovedis::node_local<ccs_matrix_local<T,I,0>> data;
size_t num_row;
size_t num_col;
```

# DESCRIPTION

A CCS (Compressed Column Storage) matrix is one of the popular sparse matrices. It has three major components while storing the non-zero elements, as explained below along with the number of rows and the number of columns in the sparse matrix.

```
val: a vector containing the non-zero elements of the compressed columns
(in column-major order) of the matrix.
idx: a vector containing the row indices for each non-zero elements in "val".
off: a vector containing the column offsets.
```

For example, if we consider the below sparse matrix:

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

then its CCS representation would be:

```
val: {1, 1, 1, 1, 2, 2, 2, 2, 4, 3, 4, 3} idx: {0, 1, 2, 3, 0, 1, 2, 3, 0, 1, 2, 3} off: {0, 2, 2, 2, 4, 8, 8, 8, 12}
```

column offset starts with 0 and it has n+1 number of elements, where n is the number of columns in the sparse matrix. The difference between i+1th element and ith element in column offset indicates number of non-zero elements present in ith column.

ccs\_matrix<T,I,0> is a two-dimensional template based distributed sparse data storage supported by frovedis. It contains public member "data" of the type node\_local<ccs\_matrix\_local<T,I,0>>. The actual distributed matrices are contained in all the worker nodes locally, thus named as ccs\_matrix\_local<T,I,0> (see manual of ccs\_matrix\_local) and "data" is the reference to these local matrices at worker nodes. It also contains dimension information related to the global matrix i.e., number of rows and number of columns in the original sparse matrix. The structure of this class is as follows:

```
template <class T, class I=size_t, class O=size_t>
struct ccs_matrix {
  frovedis::node_local<ccs_matrix_local<T,I,O>> data;  // local matrix information
  size_t num_row;  // number of rows in the global sparse matrix
  size_t num_col;  // number of columns in the global sparse matrix
};
```

For example, if the above sparse matrix with 4 rows and 8 columns is distributed row-wise over two worker nodes, then the distribution can be shown as:

```
master
                                 worker0
                                                                  worker1
ccs matrix<int,size t,size t>
                                 -> ccs matrix local<int,
                                                               -> ccs_matrix_local<int,</pre>
                                          size_t,size_t>
                                                                        size_t,size_t>
   *data: node_local<
                                                                val: vector<int>
                                 val: vector<int>
         ccs matrix
                                        (\{1,1,2,2,4,3\})
                                                                       (\{1,1,2,2,4,3\})
            local<int,
                                 idx: vector<size t>
                                                                idx: vector<size t>
                                        ({0,1,0,1,0,1})
                                                                       (\{0,1,0,1,0,1\})
          size t,size t>>
                                 off: vector<size t>
                                                                off: vector<size t>
                                        (\{0,1,1,1,2,4,4,4,6\})
                                                                       (\{0,1,1,1,2,4,4,4,6\})
    num_row: size_t (4)
                                 local_num_row: size_t (2)
                                                                local_num_row: size_t (2)
    num_col: size_t (8)
                                 local_num_col: size_t (8)
                                                                local_num_col: size_t (8)
```

The node\_local<ccs\_matrix\_local<int,size\_t,size\_t>> object "data" is simply a (\*)handle of the (->)local matrices at worker nodes.

This matrix can be loaded from a distributed crs matrix and also the matrix can be converted back to the distributed crs matrix. Thus loading/saving interfaces are not provided for distributed ccs matrix.

# Constructor Documentation

## ccs\_matrix ()

This is the default constructor which creates an empty distributed ccs matrix without any memory allocation at worker nodes.

## ccs\_matrix (crs\_matrix<T,I,0>& m)

This is the implicit conversion constructor to construct a distributed ccs matrix from the input distributed crs matrix of the same types.

## **Public Member Function Documentation**

# void debug\_print ()

It prints the information related to the distributed compressed column storage (val, idx, off, number of rows and number of columns) on the user terminal node-by-node. It is mainly useful for debugging purpose.

# **Public Data Member Documentation**

#### data

An instance of node\_local<ccs\_matrix\_local<T,I,O>> type to contain the reference information related to local matrices at worker nodes.

#### num\_row

A size t attribute to contain the total number of rows in the 2D matrix view.

#### num\_col

A size t attribute to contain the total number of columns in the 2D matrix view.

# SEE ALSO

ccs\_matrix\_local, crs\_matrix