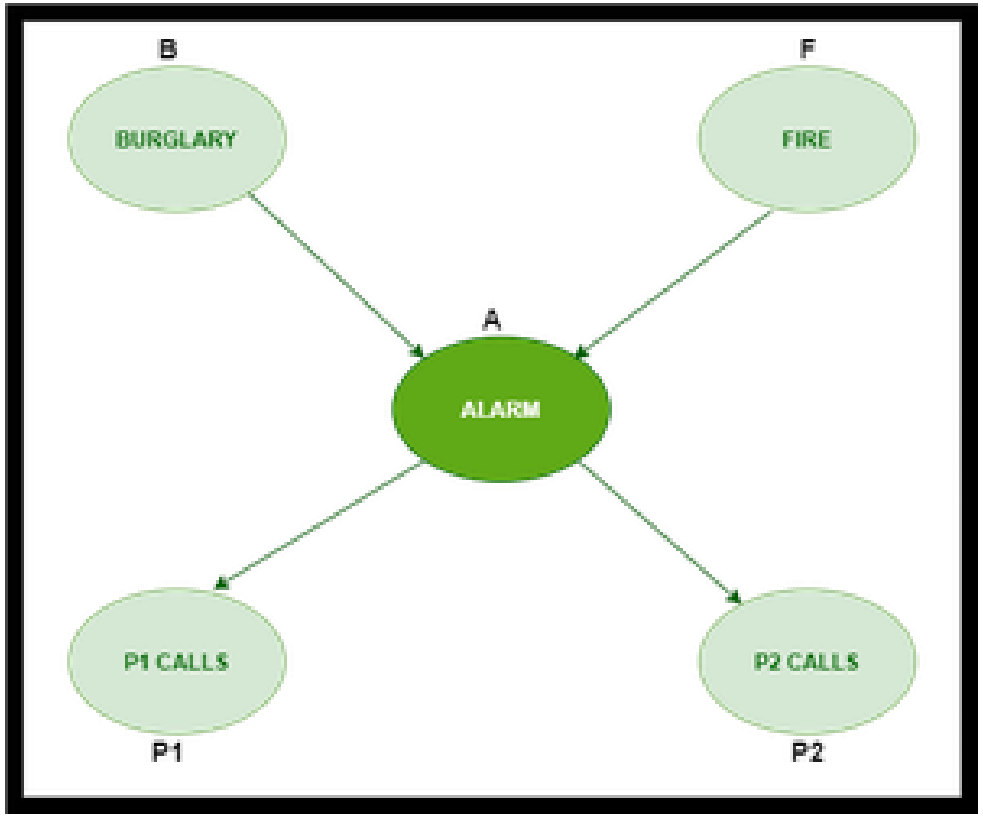
Powerset reduction with MPI

--Vivek kuchibhotla

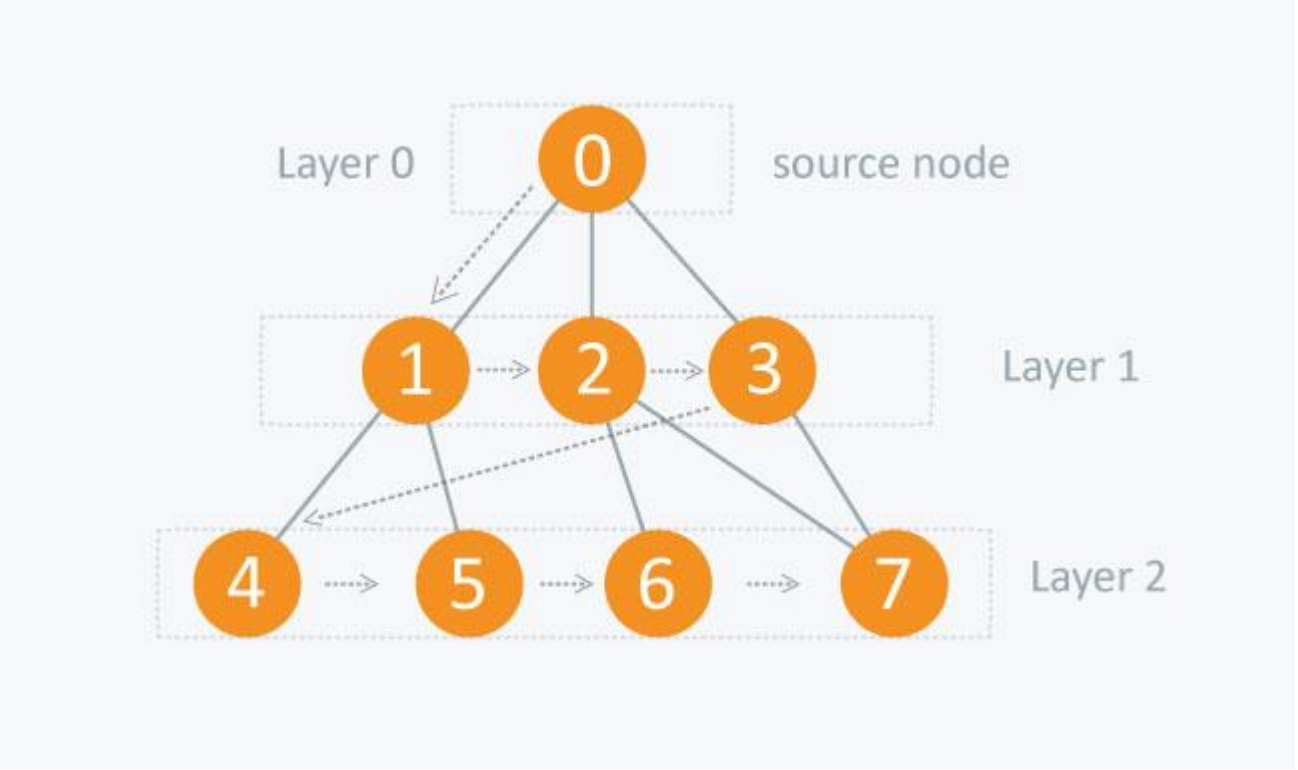
Application being used

- Solving Bayesian inference
- Runtime of O(2^n * n^2)



Problem with layer wise traversal

- Varying sizes of layers
- Job scheduling required
- Movement of data is not consistent

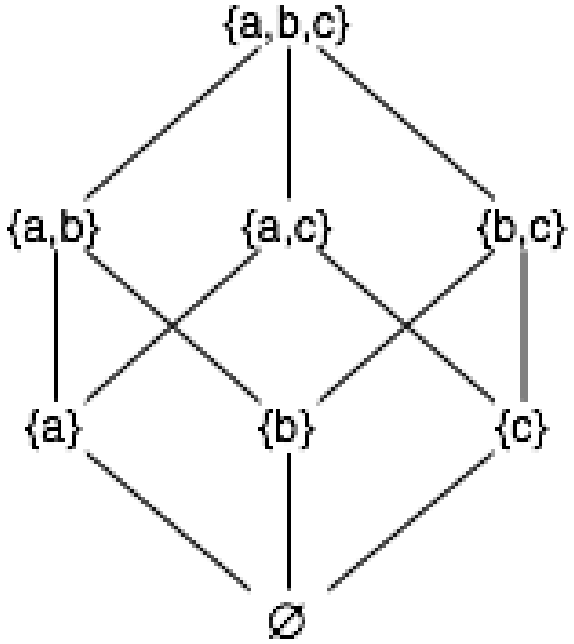


Why is powerset traversal useful

- Powersets can be represented as hypercubes
- Hypercubes scale very well with increasing processors
- Data dependency will always be with processors that are connected.
- Needs an Initial warm-up phase and can go through with all the processors.

{a,b,c}

{},
{a}, {b}, {c},
{a,b}, {a,c}, {b,c},
{a,b,c}



Approaches

1. Use MPI_Reduce, MPI_Scatter calls recursively
2. Add a new MPI call, MPI_Hypercube_Reduce.

Organizing processors and setup

- Need to initially organize the processors in Hyper cube formation with **MPI_Cart_create**
- Load the data into corresponding processors.
- Create the warm-up loop
- Finished work until here.

Continuing the work

- Work on the scatter , reduce calls to move data around until we reach the end of the powerset tree.
- If time permits implement a MPI call that does the same.
- Finished creating the setup and compute with communication built and compute performed.

Create hypercube struct

```
MPI_Comm nthCube;
int nDim = log2(size);
int processPerDim[nDim];
//std::cout << "ndim is " << nDim << std::endl;
int period[nDim];
for (int i = 0; i < nDim; ++i) {
    processPerDim[i] = 2;
    period[i] = 1;
}

MPI_Cart_create(MPI_COMM_WORLD, nDim, processPerDim, period, true, &nthCube);

int rankInDim;
MPI_Comm_rank(nthCube, &rankInDim);

int rank_source, rank_desta, rank_destb, rank_destc, rank_destd;
int rank_adjacent[nDim];
for(int i=0;i<nDim;i++){
    MPI_Cart_shift(nthCube, i,1,&rank_source, &rank_adjacent[i]);
}
```

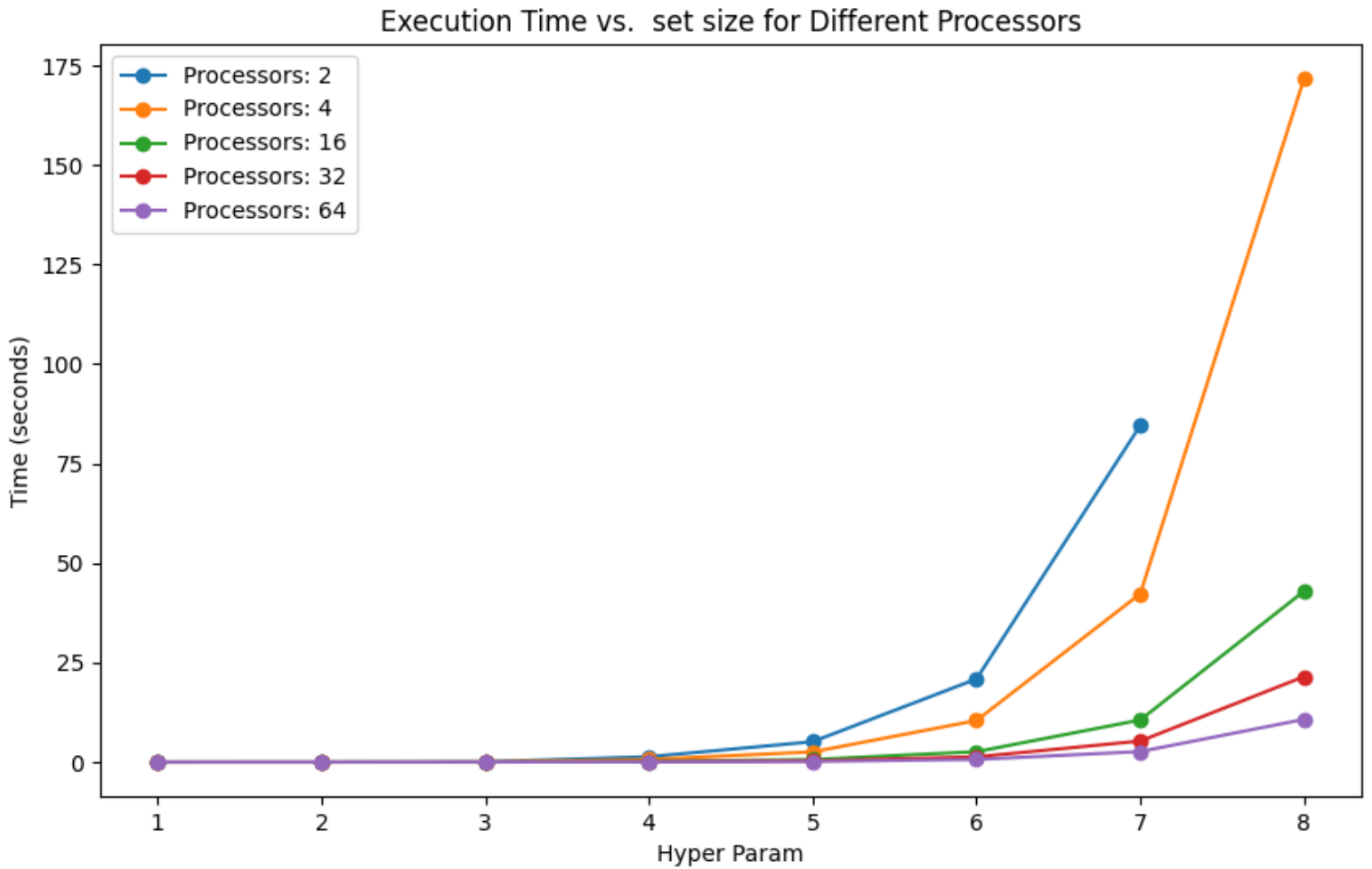
The Warmup

```
for(int ij=0;ij<pow(2, power_set_size)/size;ij++){
    for (int i = 0; i <= nDim; i++) {
        vector<int> processors_to_process = generate_binary_strings(nDim, i);
        for(int j=0;j<processors_to_process.size();j++){
            if(processors_to_process[j] == rankInDim){

                /*
                    Wait on recieving data from previous processors
                */
                vector<int> to_recv = get_numbers_with_flipped_one(rankInDim, nDim);
                if(to_recv.size() > 0){
                    int recv_data[to_recv.size()];
                    std::vector<MPI_Request> requests(to_recv.size());
                    for(int k = 0;k < to_recv.size(); k++){
                        //std::cout << "recv from  " << to_recv[k] << std::endl;
                        MPI_Irecv(&recv_data[k], 1, MPI_INT, /*source=*/ to_recv[k], /*tag=*/ 0, nthCube, &requests[k]);
                    }
                    int completed_index;
                    MPI_Waitany(to_recv.size(), requests.data(), &completed_index, MPI_STATUS_IGNORE);
                }
                Process();
                vector<int> to_send = get_numbers_with_flipped_zero(rankInDim, nDim);
                for(int k=0;k<to_send.size();k++){
                    int aj = 10;
                    //std::cout << "sending to  " << to_send[k] << std::endl;
                    MPI_Send(&aj, 1, MPI_INT, to_send[k], 0, nthCube);
                }
            }
        }

    }
}
```

Testing and performance

- Ran a simple test with a single processor on a test data set Alarm.
- Created synthetic data to simulate complex computation on top of a power set traversal problem.
- Will also primarily investigate strong and weak scaling.

Scaling for now



Future Work

- Get real world data
- Understand weak vs strong scaling
- Dynamic data movement

References

- https://www.bnlearn.com/bnrepository/discrete-small.html
- https://www.sciencedirect.com/science/article/pii/S0743731513000622