

Matrix vector multiplication:

Now Suppose we want to compute Matrix vector multiplication. Suppose A is a matrix of size $m \times n$ and B is a vector of size $n \times 1$. So the result C will be of size $m \times 1$.

methodology:

we can do the multiplication in sequential method in the following way

```
loop i from 0 to m-1
  loop k from 0 to n-1
    compute C[i][0] += A[i][k]*B[k][0];
  end loop
end loop
```

parallelization:

matrix vector multiplication can be visualized as m different dot products of two vectors each of size n and there are m different dot products as the size of the matrix is of $m \times n$.

The diagram shows a 3x3 matrix \mathbf{X} multiplied by a 3x1 vector. The first row of the matrix, [2, 1, 2], is highlighted in yellow and labeled 'slice' with an arrow. The first column of the vector, [1, 0, 1], is also highlighted in yellow. The result is shown as a single value in a vector, calculated as the dot product of the slice and the column: $2*1 + 1*0 + 2*1$.

$$\begin{bmatrix} 2 & 1 & 2 \\ 3 & 2 & 3 \\ 4 & 1 & 1 \end{bmatrix} \mathbf{X} \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 2*1 + 1*0 + 2*1 \\ \\ \end{bmatrix}$$

Here each of the slice is treated as a different vectors. So the matrix a can be treated as a collection of m different row vectors of size n . product of the matrix with the vector is nothing but dot product of the row vectors in the matrix(ie. Slice in the picture) and the vector n and storing the result in the respective location of another vector C.

So to do this in parallel one can divide the matrix into sub matrices with size $(m/p, n)$, p being the number of the processes. And then compute m/p dot products locally (can be parallelized) and storing at the respective location.