Matrix vector multiplication by one to all broadcast and all to one reduction communication operation on a 16-node mesh

(Sequential)

Example

Input Vector (x)

4	5	6	7

Output Vector (y=?)

Input Matrix (A)

11	12	13	14
15	16	17	18
19	20	21	22
23	24	25	26

Step1. Colum wise one to all broadcast of input vector (x)

Step1.		Input Vector (x)			
		P0 4	P1 5	P2 6	P3 7
		Input Matrix (A)			
P0	Output Vector (y)	P0 11 4	P1 12 5	P2 13 6	P3 14 7
P4		P4 15 4	P5 16 5	P6 17 6	P7 18 7
P8		P8 19 4	P9 20 5	P10 21 6	P11 22 7
P12		P12 23 4	P13 24 5	P14 25 6	P15 26 7

All columns operations are done in parallel

P0->P4, P0->P8, P0->P12 P1->P5, P1->P9, P1->P13

P2->P6, P2->P10, P2->P14

P3->P7, P3->P11, P3->P15

Step2. Multiplication of input matrix (A) elements with the input vector (x) element received in step1, at each node of mesh

Step2.		Input Vector (x)			
		P0 4	P1 5	P2 6	P3 7
		Input Matrix (A)			
P0	Output Vector (y)	P0 44	P1 60	P2 78	P3 98
P4		P4 60	P5 80	P6 102	P7 126
P8		P8 76	P9 100	P10 126	P11 154
P12		P12 92	P13 120	P14 150	P15 182

Step3. Row wise all to one reduction operation to get the output vector (y)

Step2.		Input Vector (x)			
		P0 4	P1 5	P2 6	P3 7
		Input Matrix (A)			
P0 280	Output Vector (y)	P0 44	P1 60	P2 78	P3 98
P4 368		P4 60	P5 80	P6 102	P7 126
P8 456		P8 76	P9 100	P10 126	P11 154
P12 544		P12 92	P13 120	P14 150	P15 182

P0<-P1, P0<-P2, P0<-P3 P4<-P5, P4<-P6, P4<-P7

P8<-P9,P8<-P10,P8<-P11

P12<-P13,P12<-P14,P12<-P15

One to all broadcast operation on a 16-node mesh (Recursive Doubling)

3	7	11	15
2	6	10	14
1	5	9	13
0 “HI”	4	8	12

Step1. (0^{th} row recursive doubling)

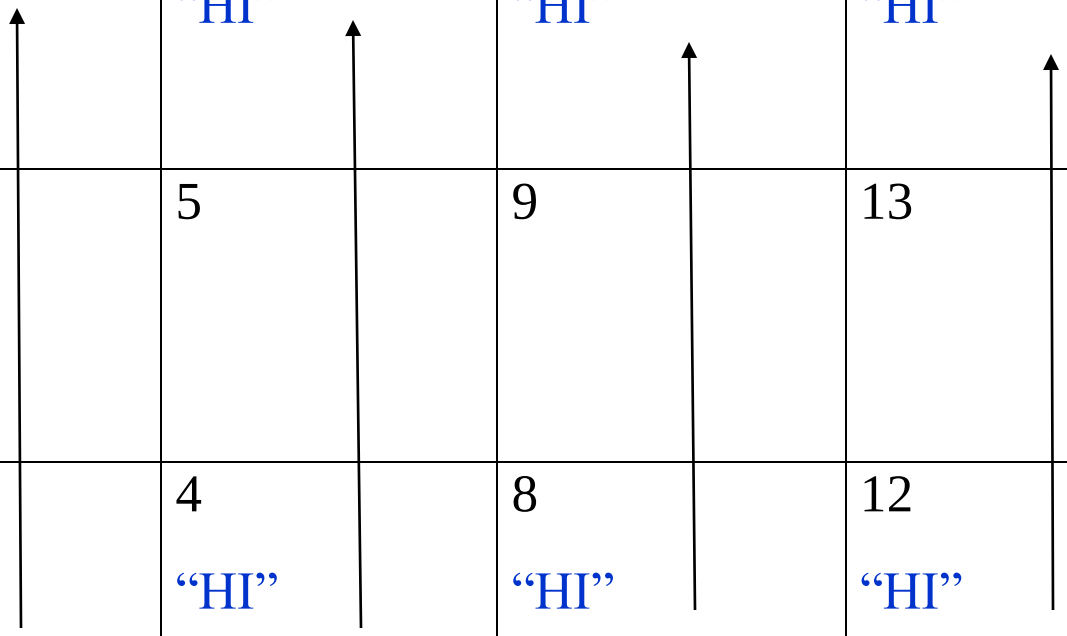
3	7	11	15
2	6	10	14
1	5	9	13
0 “HI”	4	8 “HI”	12

Step2. (0^{th} row recursive doubling)

3	7	11	15
2	6	10	14
1	5	9	13
0 “HI”	4 “HI”	8 “HI”	12 “HI”

Step3. (All columns recursive doubling)

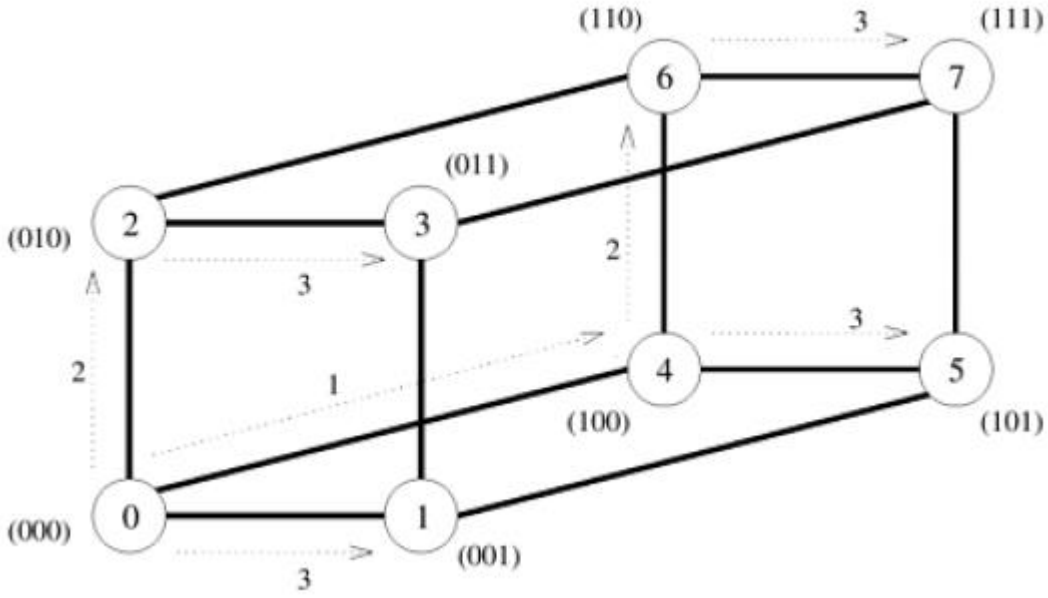
3	7	11	15
2 “HI”	6 “HI”	10 “HI”	14 “HI”
1	5	9	13
0 “HI”	4 “HI”	8 “HI”	12 “HI”



Step4. (All columns recursive doubling)

3 “HI”	7 “HI”	11 “HI”	15 “HI”
2 “HI”	6 “HI”	10 “HI”	14 “HI”
1 “HI”	5 “HI”	9 “HI”	13 “HI”
0 “HI”	4 “HI”	8 “HI”	12 “HI”

One to all broadcast on Hypercube



One to all broadcast on a balanced binary tree of 8 nodes