MapReduce

2 step

$$n\left(\overbrace{\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}}^{l}\right. \quad \overbrace{\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}}^{m}$$

$$A \qquad\qquad B$$

m duplication

$$\langle \underbrace{i \quad \overset{1}{\underset{m=2}{\vdots}} \quad k}_{\text{key}} , \underbrace{a_{ik}}_{\text{value}} \rangle \text{ for } A$$

$$\langle \overset{1}{\underset{n=2}{\vdots}} \quad j \quad k , b_{kj} \rangle \text{ for } B$$

n duplication

Step 1
output
Map function

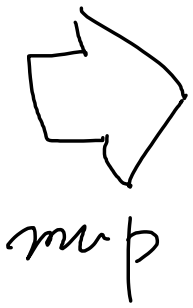
when $k = 1, 2, \ldots, l$

duplicate 2 <= m

Matrix

A

B



<1 1 1, a_{11}>
<1 2 1, a_{11}>
<1 1 2, a_{12}>
<1 2 2, a_{12}>
<2 1 1, a_{21}>
<2 2 1, a_{21}>
<2 1 2, a_{22}>
<2 2 2, a_{22}>

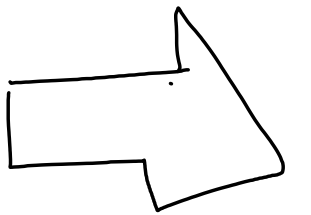
for A

<1 1 1, b_{11}>
<2 1 1, b_{11}>
<1 2 1, b_{12}>
<2 2 1, b_{12}>
<1 1 2, b_{21}>
<2 1 2, b_{21}>
<1 2 2 b_{22}>
<2 2 2 b_{22}>

for B

Shuffle!

<1 1 1, [a_{11}, b_{11}]>
<1 1 2, [a_{12}, b_{21}]>
<1 2 1, [a_{11}, b_{12}]>
<1 2 2, [a_{12}, b_{22}]>
<2 1 1, [a_{21}, b_{11}]>
<2 1 2, [a_{22}, b_{21}]>
<2 2 1, [a_{21} b_{12}]>
<2 2 2, [a_{22} b_{22}]>

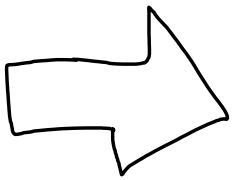


11 $a_{11} \times b_{11}$
11 $a_{12} \times b_{21}$
12 $a_{11} \times b_{12}$
12 $a_{12} \times b_{22}$
21 $a_{21} \times b_{11}$
21 $a_{22} \times b_{21}$
22 $a_{21} \times b_{12}$
22 $a_{22} \times b_{22}$

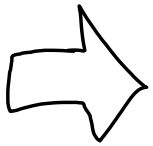
in step 2

Map

그래프



11	$a_{11}b_{11}$
11	$a_{12}b_{21}$
12	$a_{11}b_{12}$
12	$a_{12}b_{22}$
21	$a_{21}b_{11}$
21	$a_{22}b_{21}$
22	$a_{21}b_{12}$
22	$a_{22}b_{22}$



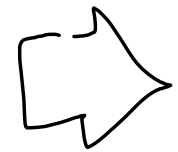
Shuffle

$\langle 11 \quad [a_{11}b_{11}, a_{12}b_{21}] \rangle$

$\langle 12 \quad [a_{11}b_{12}, a_{12}b_{22}] \rangle$

$\langle 21 \quad [a_{21}b_{11}, a_{22}b_{21}] \rangle$

$\langle 22 \quad [a_{21}b_{12}, a_{22}b_{22}] \rangle$



Reduce

11	$a_{11}b_{11} + a_{12}b_{21}$
12	$a_{11}b_{12} + a_{12}b_{22}$
21	$a_{21}b_{11} + a_{22}b_{21}$
22	$a_{21}b_{12} + a_{22}b_{22}$

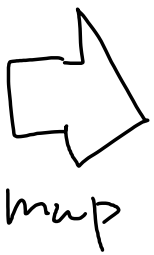
One step Version

for A, $\langle i \; \begin{matrix} 1 \\ 2 \\ \vdots \\ m \end{matrix} \; , (k, a_{ik}) \rangle$

for B $\langle \begin{matrix} 1 \\ 2 \\ \vdots \\ n \end{matrix} \; j \; , (k, b_{kj}) \rangle$

map output

map



2 duplicate

11 , (1 a_{11})
12 , (1 a_{11})
11 , (2 a_{12})
12 , (2 a_{12})
21 , (1 a_{21})
22 , (1 a_{21})
21 , (2 a_{22})
22 , (2 a_{22})

11 (1 b_{11})
21 (1 b_{11})
11 (2 b_{21})
21 (2 b_{21})
12 (1 b_{12})
22 (1 b_{12})
12 (2 b_{22})
22 (2 b_{22})

Shuffle

11 [(1, a_{11}), (1 b_{11}), (2 a_{12}), (2 b_{21})]

12 [(1 a_{11}) (1 b_{12}), (2 a_{12}) (2 b_{22})]

21 [(1 a_{21}) (1 b_{11}) (2 a_{22}) (2 b_{21})]

22 [(1 a_{21}) (1 b_{12}) (2 a_{22}) (2 b_{22})]

Reduce

< 11, $a_{11}b_{11} + a_{12}b_{21}$ > < 21, $a_{21}b_{11} + a_{22}b_{21}$ >

< 12, $a_{11}b_{12} + a_{12}b_{22}$ > < 22, $a_{21}b_{12} + a_{22}b_{22}$ >