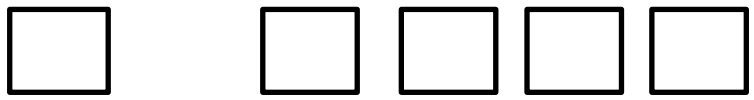
parallel computing

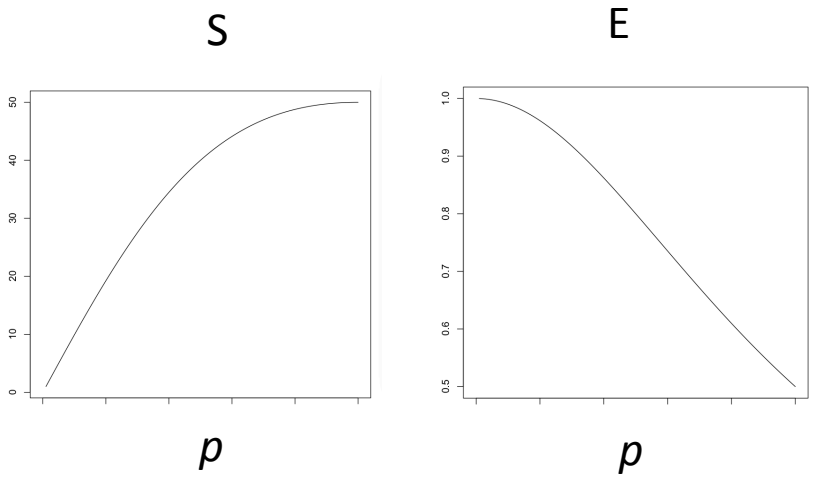


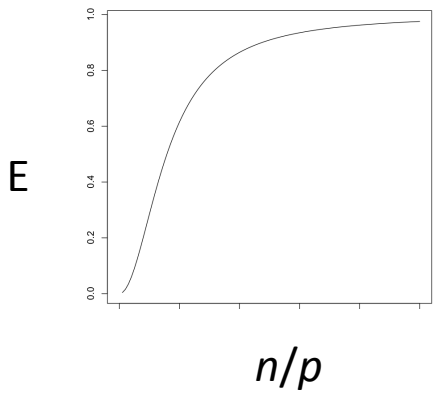
speedup, $S = T_1 / T_p$, time with *p* processors vs with one

efficiency, $E = T_1 / p\, T_p$

scalable algorithm – E increasing function of *n*/*p*

where *n* is 'problem size'





parallel programming paradigms

shared memory

- partition work

$F(w_p)$:

shared a

lock(a[i])

work(w_p)

unlock(a[i])

message passing

- partition data

F(p):

a_p=a[p … p+(n/p)-1]

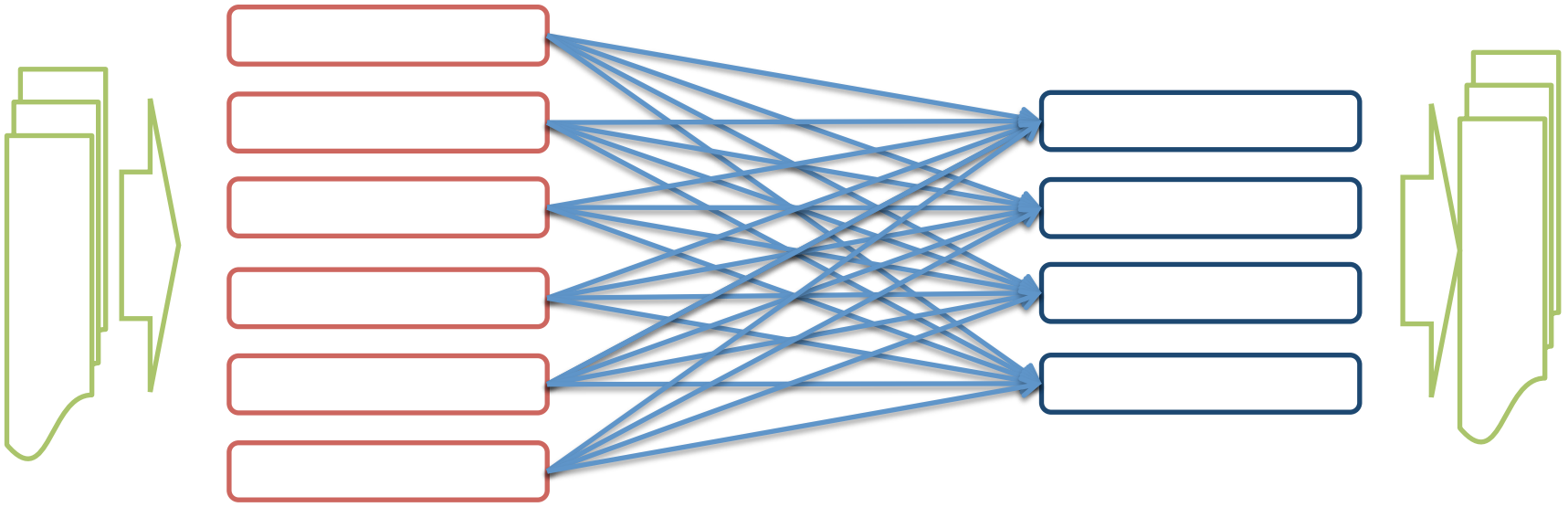
work(w)

exchange data(a_p)

shared + partition data; message-passing + partition work also possible

map-reduce: message-passing, data-parallel, pipelined work, higher level

map-reduce



mappers:
take in k1, v1 pairs
emit k2, v2 pairs
k2,v2 <- map(k1,v1)

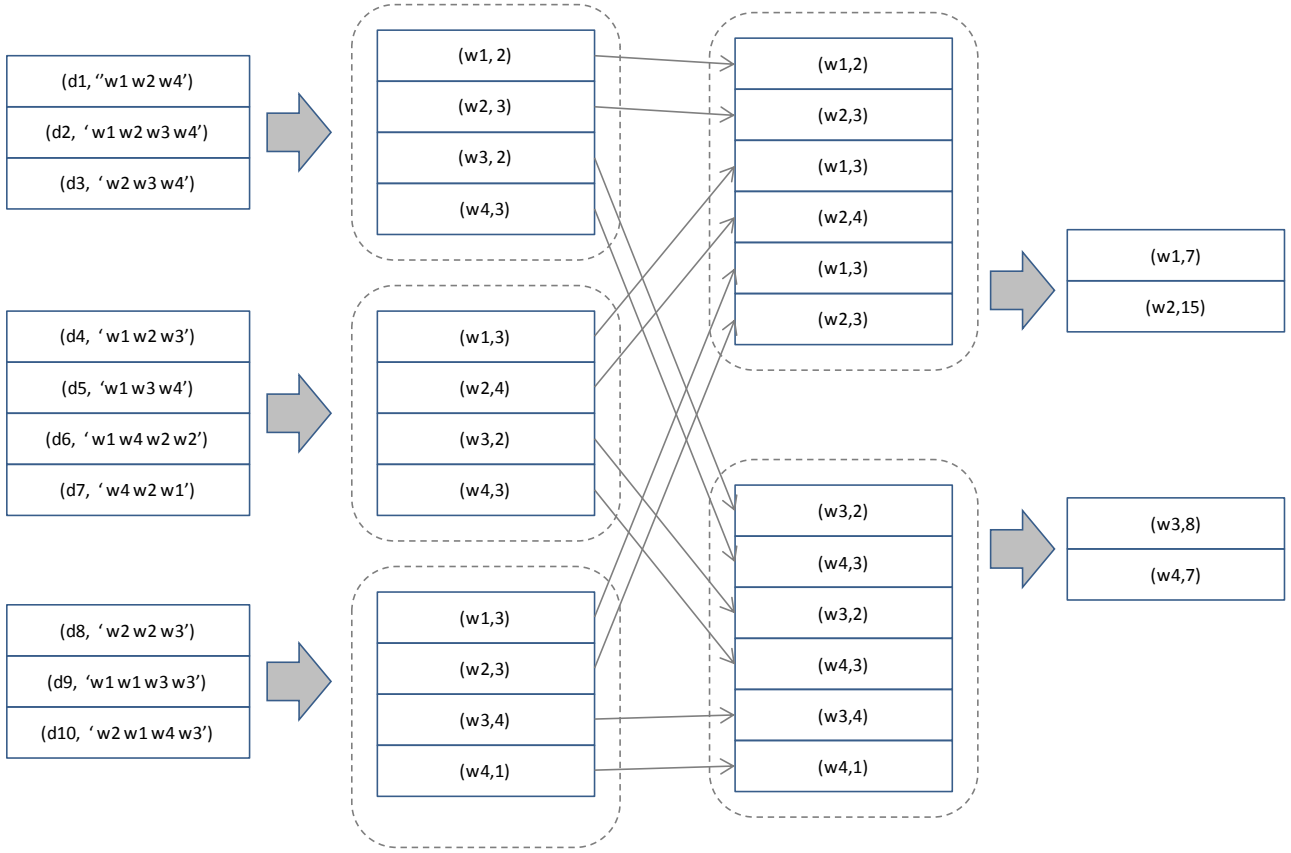
reducers:
receive all pairs for some k2
combine these in some manner
k2,f_r(…v2….) <- reduce(k2, […v2…])

map-reduce platform responsible for *routing* pairs to reducers
map-reduce reads data and *writes* fresh data; is a *batch* process

map-reduce

Map: $(d_k, `w_1 \ldots w'_n) \rightarrow [(w_i, c_i)]$ document -> word-count pairs

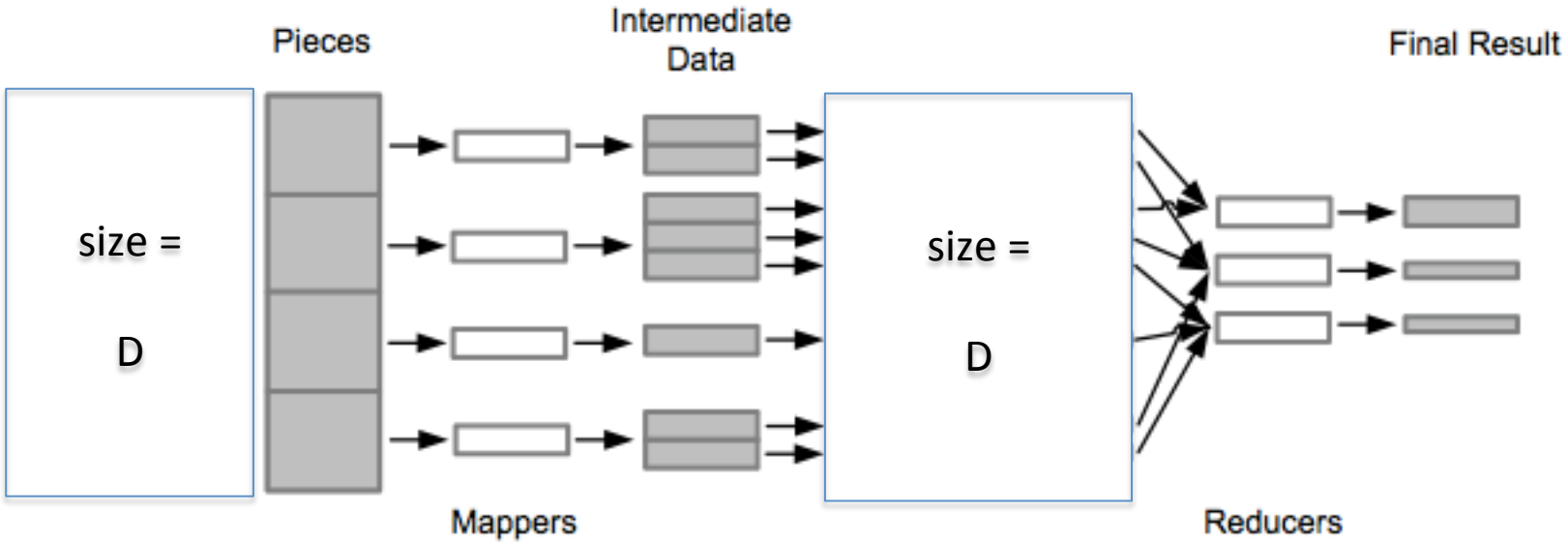
Reduce: $(w_i, [c_i]) \rightarrow (w_i, \sum_i c_i)$ word, count-list -> word-count-total



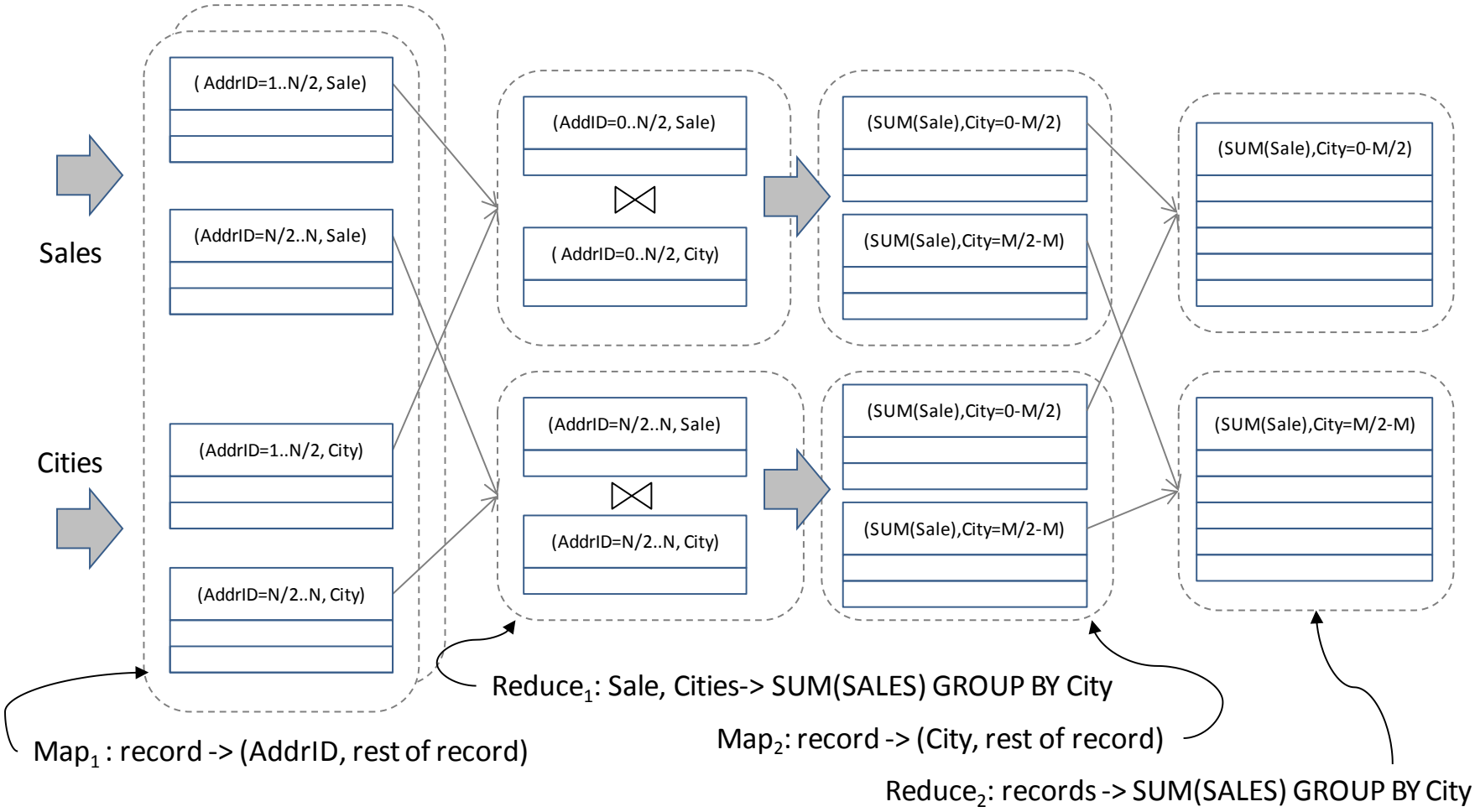
map, reduce … also ‘combine’

how much data is produced by map?

- each word is emitted multiple times!
- combiner : sum up word-counts per mapper before emitting



database join using map-reduce



SQL: SELECT SUM(Sale), City FROM Sales, Cities WHERE Sales.AddrID=Cities.AddrID GROUP BY City

real-world example

lots of data …

paper, author, contents

million such papers, million authors, millions of possible terms ('phrases' occurring in contents)

problems:

top 10 terms for each author; top 10 authors per term…

'database' person's solution ….

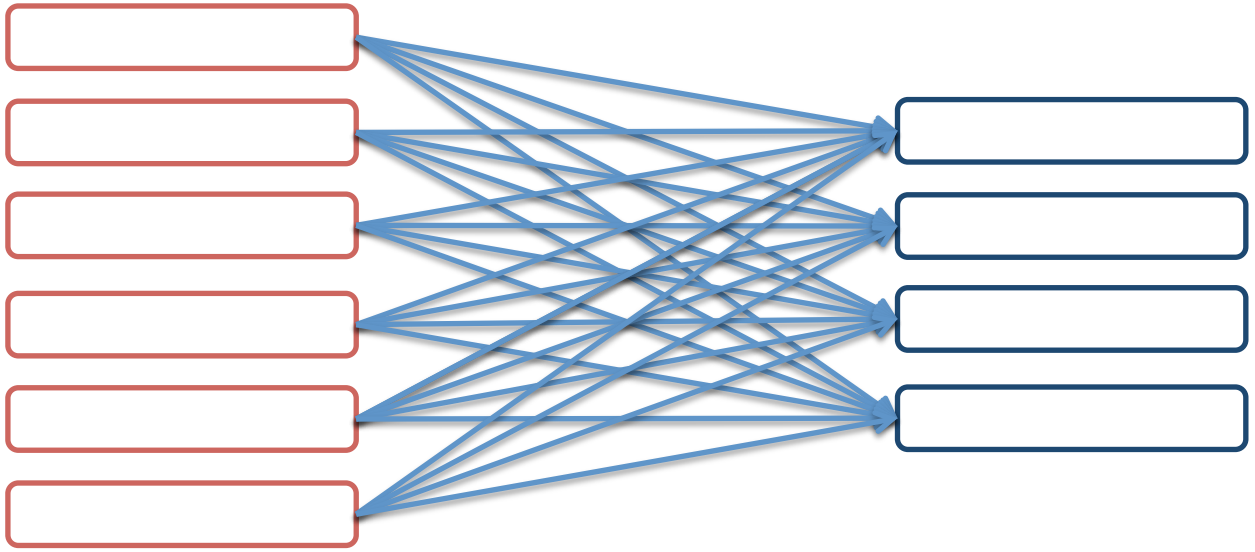
Q = select id, word, author
from P where in(w,content)

select count(), word, author
from Q group by word

P million

Q trillions (million x million)!

top-k words per author in map-reduce



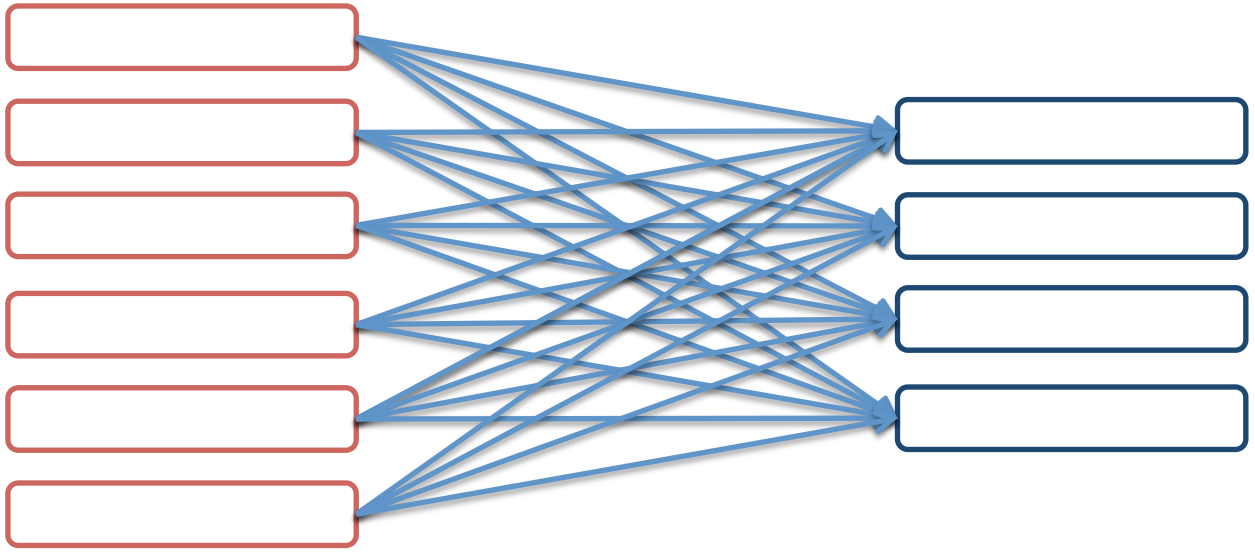
map:
emit word, author

reduce:
reduce-key = word+author
reduce-function = count

suffers from same problem – trillion combinations!

- map-reduce alone is not enough – *approach needs to change!*

top-k words per author in map-reduce

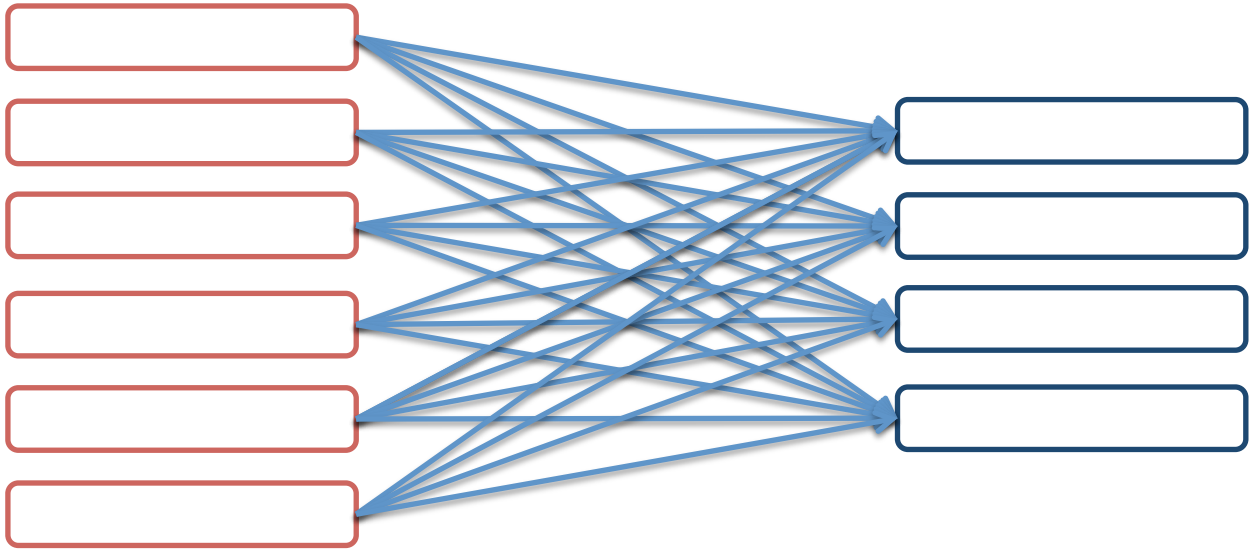


map:
  emit author, contents

reduce:
  reduce-key = author
  reduce-function = **F()**

F(): for each author:
  scan all inputs and compute word-counts .. insert into w
  sort w, output the top k, delete w and reinitialize to [ ]

indexing in map-reduce

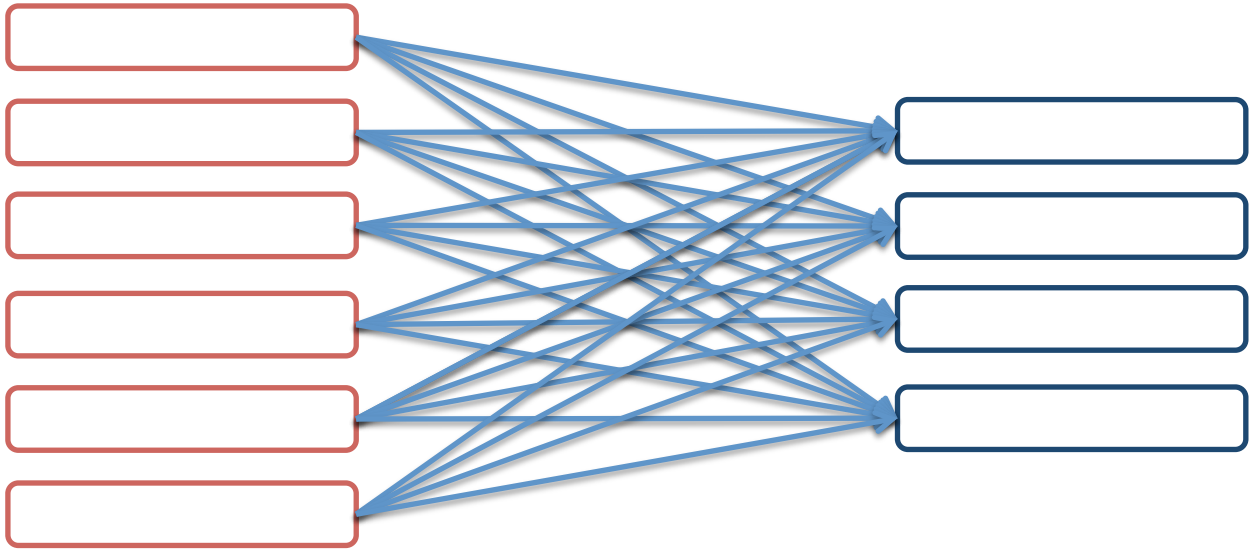


map:
produce a partial index
i.e. emit w -> postings-list

reduce:
reduce-key = word
merge partial indexes
i.e. merge postings per word

what about sorting by either document-id, or page-rank etc. ?

LSH in map-reduce



map:
emit doc-id, k hash-values

reduce:
reduce-key = hashes
emit doc-pairs for each key

will a document-pair be emitted by more than one reducer?

inside map-reduce