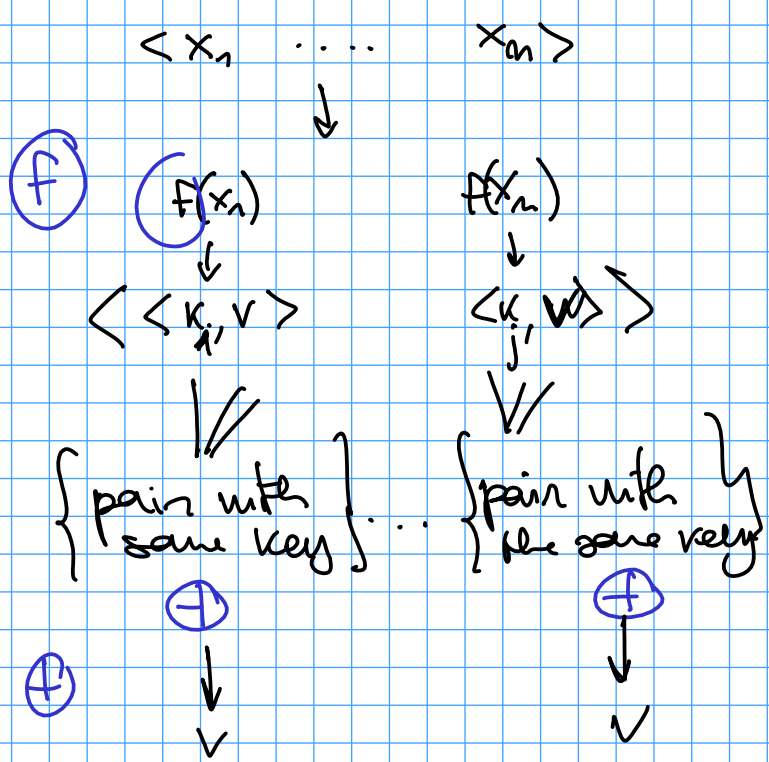
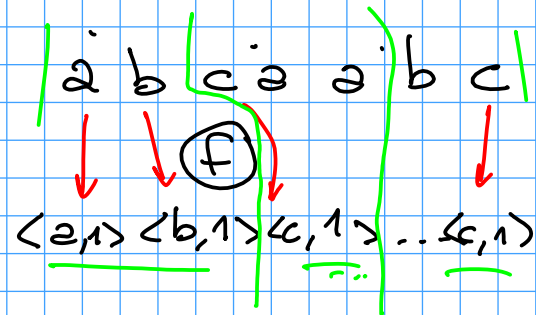


**MAP REDUCE**

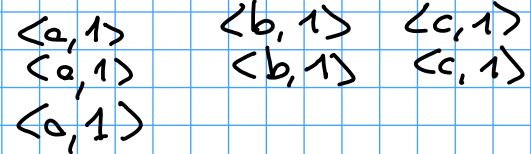


**Word count**

map

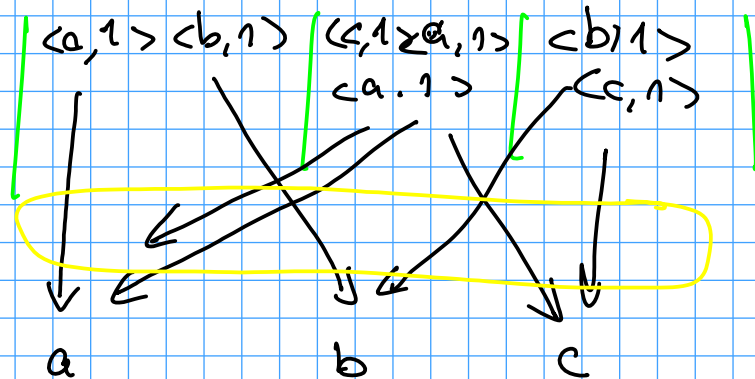


reduce

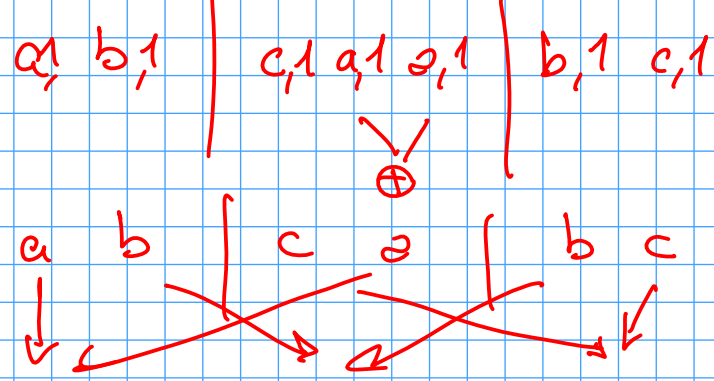


$\oplus = \text{SUM}$

$\langle a, 3 \rangle \quad \langle b, 2 \rangle \quad \langle c, 1 \rangle$

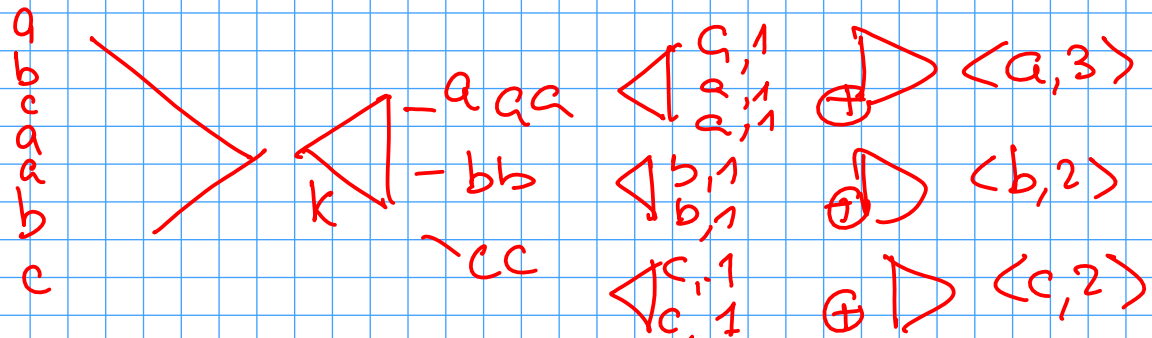
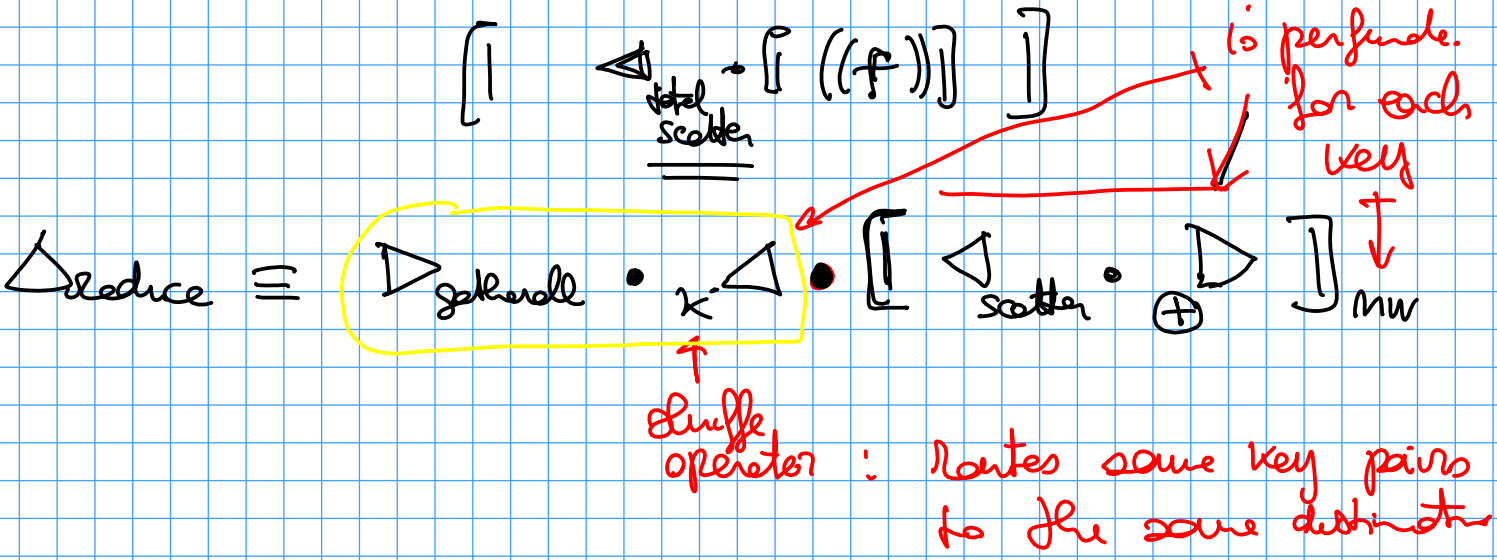
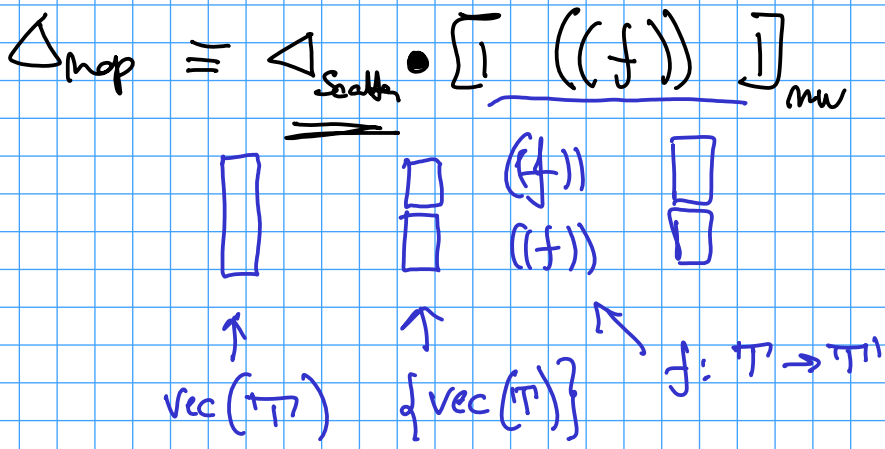


node (i)  
processes  
all keys  
with  $\text{hash}(k) =$   
...

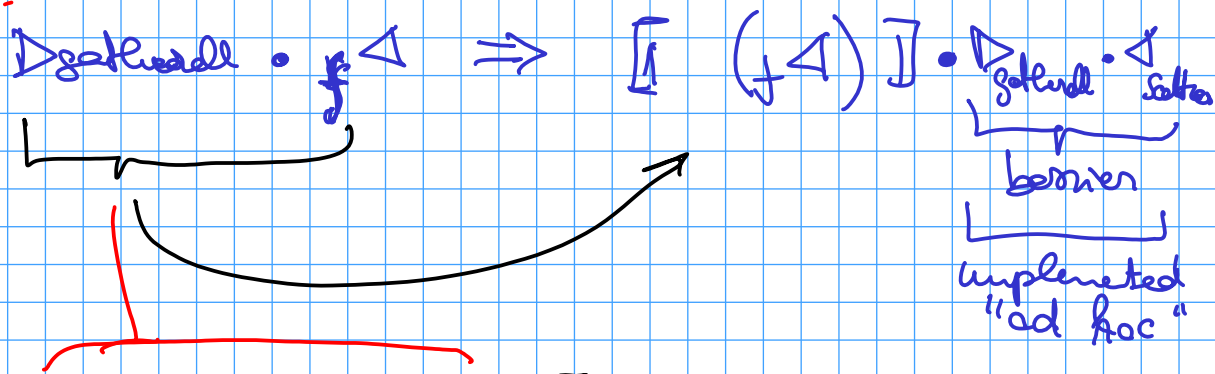


Map Reduce  $\Delta_{Map}$   $\Delta_{Reduce}$  MR  $\equiv$   $\Delta_{Map}$   $\cdot$   $\Delta_{Reduce}$

function for the map

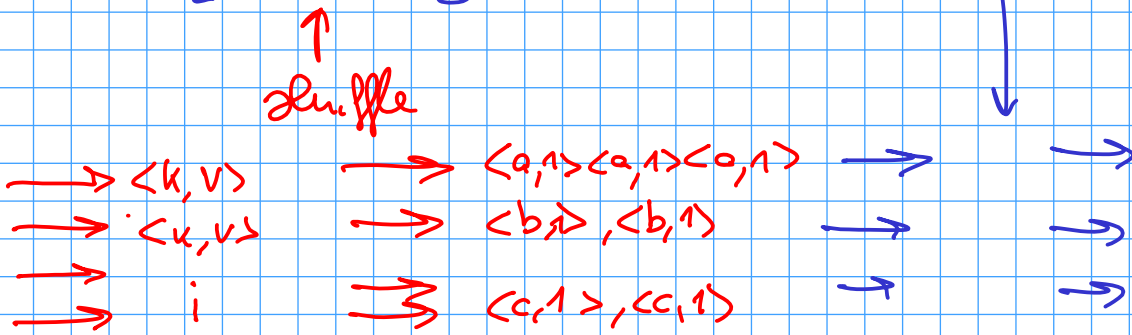


Rule ::



$$\Delta_{\text{reduce}} \equiv \Delta_{\text{shuffle}} \cdot k \cdot \Delta \cdot [ [ \Delta_{\text{scatter}} \cdot \oplus \cdot \Delta ] ]_{\text{nw}}$$

$$\Delta_{\text{reduce}} = [ [ (k \cdot \Delta) ] ] \cdot [ [ \Delta_{\text{scatter}} \cdot \oplus \cdot \Delta ] ]$$

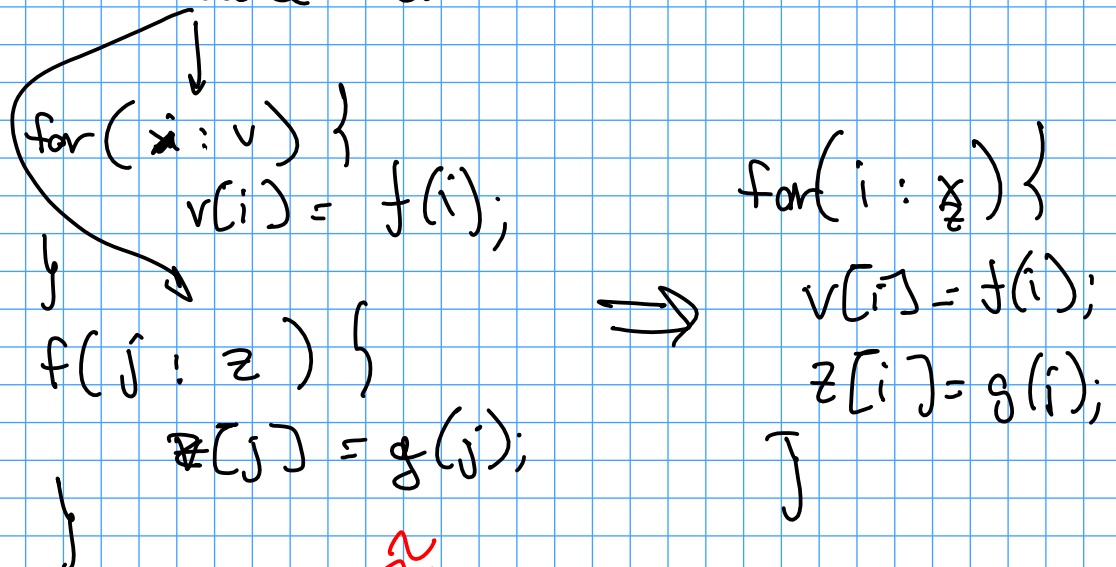


Rule  $[ [ \Delta_1 ] ] \cdot [ [ \Delta_2 ] ] = [ [ \Delta_1 \cdot \Delta_2 ] ]$

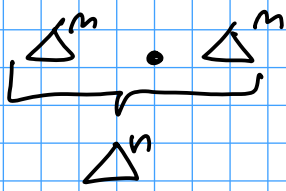
$$\Delta_{\text{reduce}} \equiv [ [ (k \cdot \Delta) \cdot \Delta_{\text{scatter}} \cdot \oplus \cdot \Delta ] ]$$

same dimension

E.g.



$$[ [ f ] ] \cdot [ [ s ] ] = [ [ f \cdot s ] ]$$

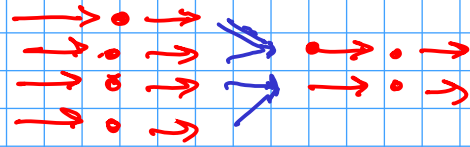


$$\Delta_{\text{map}} = \Delta_{\text{reduce}}$$

$$\left[ \begin{array}{c} \phantom{\Delta} \\ \phantom{\Delta} \\ \phantom{\Delta} \end{array} \right]_{n'} \bullet \left[ \begin{array}{c} \phantom{\Delta} \\ \phantom{\Delta} \\ \phantom{\Delta} \end{array} \right]_{n''}$$

$$n' = n'' \leftarrow \text{!}$$

If  $n' \neq n''$



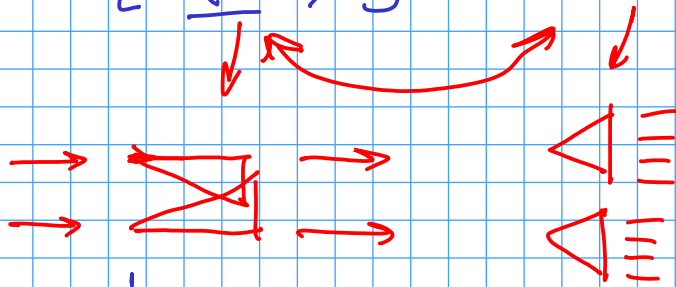
$$n' = 4 \quad \downarrow \text{!} \quad n'' = 2$$



$$\Delta_{map} \equiv \triangleleft_{scatter} \cdot \left[ \left[ (f) \right] \right]_{mv}$$

$$\Delta_{MR} = \Delta_{map} \cdot \Delta_{reduce}$$

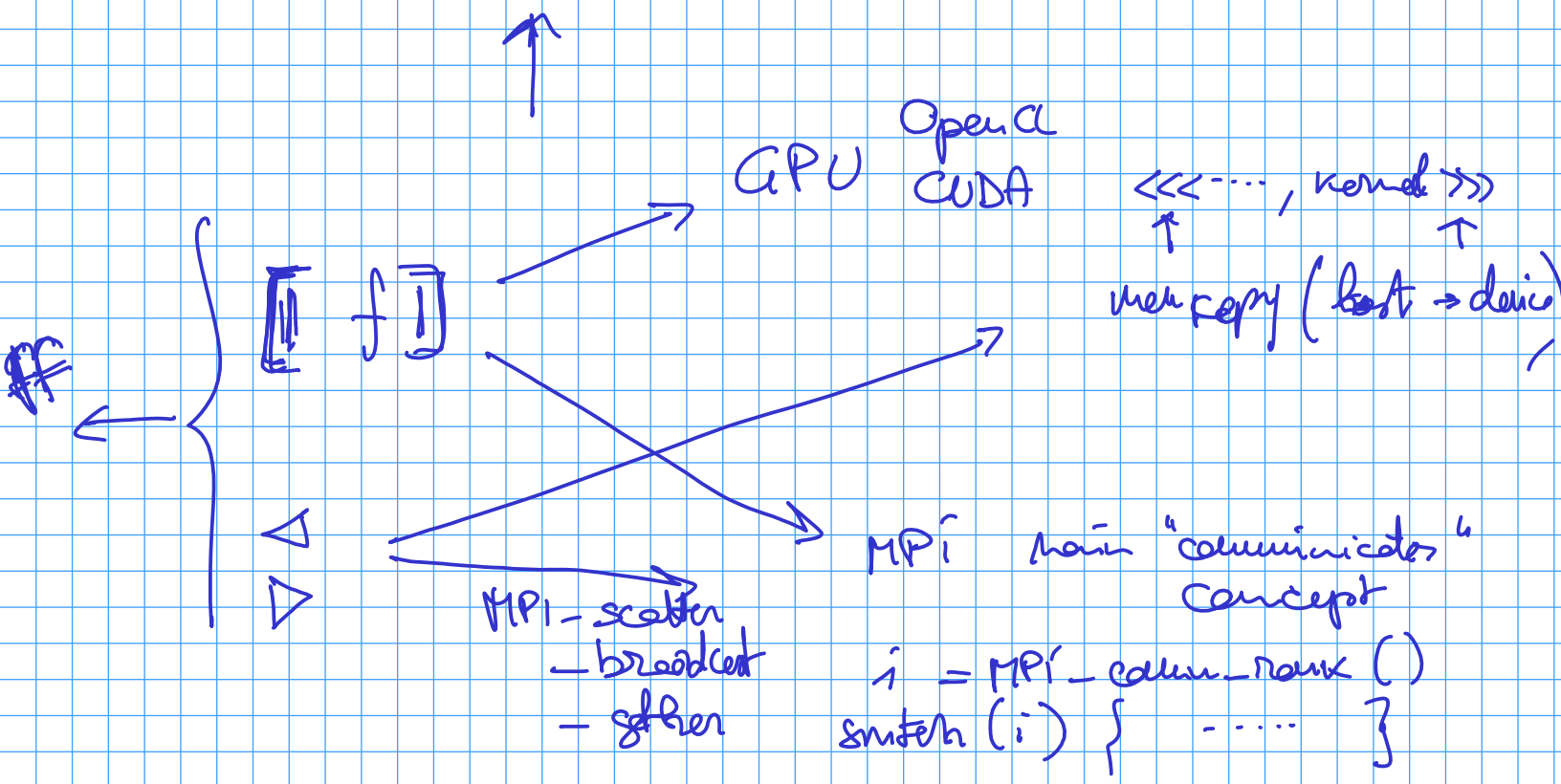
$$\Delta_{reduce} = \left[ \left[ (k\Delta) \right] \right] \cdot \left[ \left[ \triangleleft_{scatter} \cdot \oplus \right] \right] \equiv$$

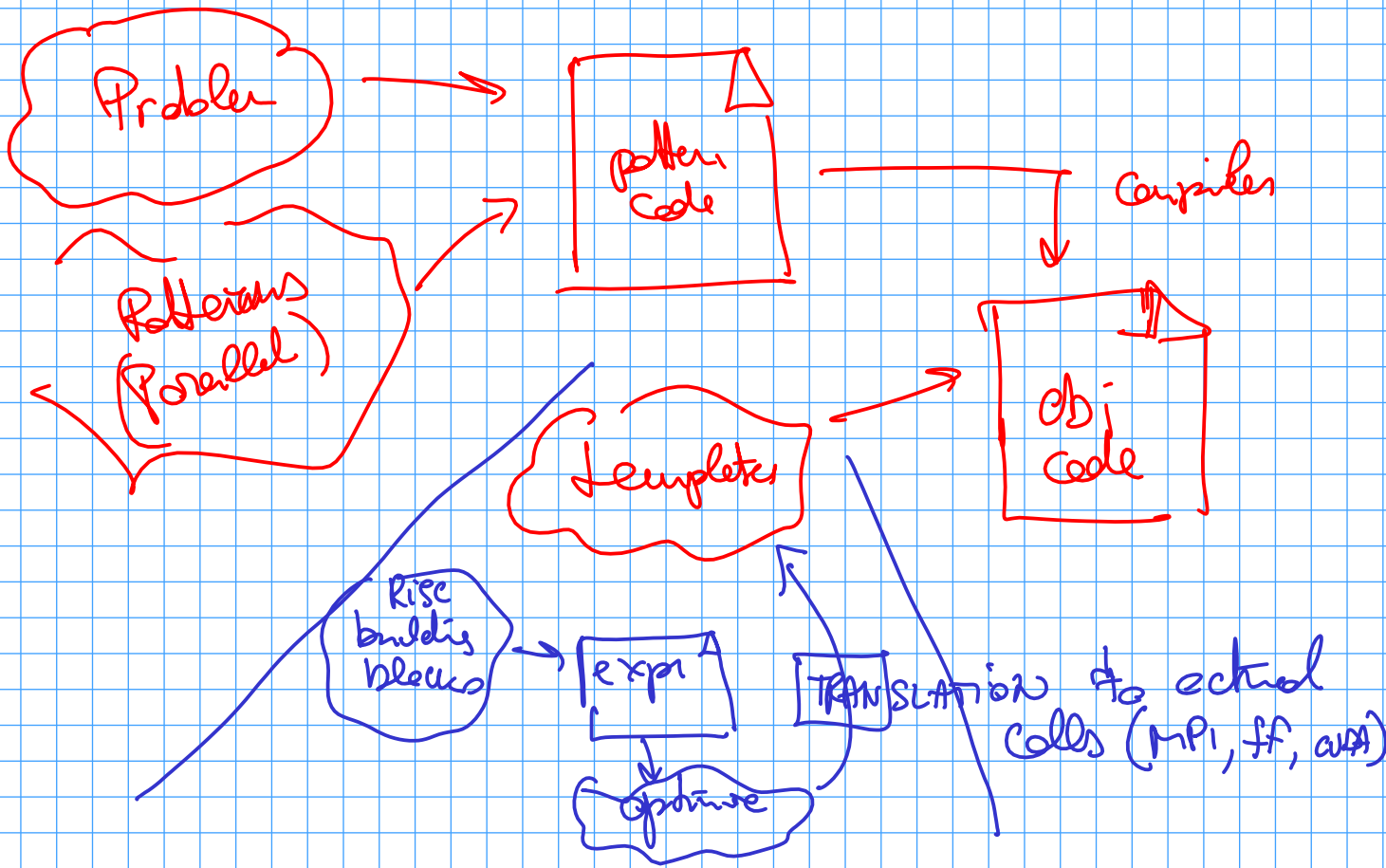


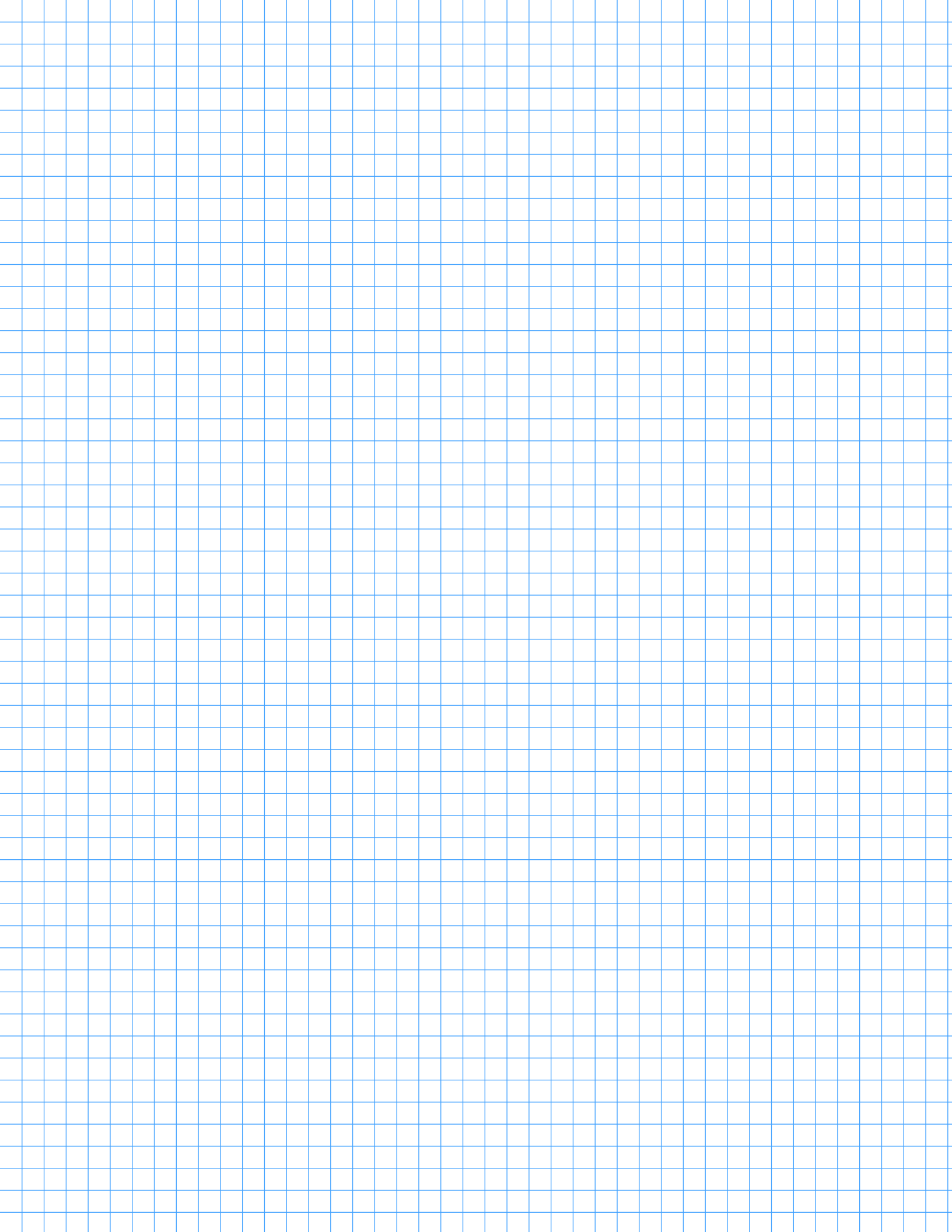
$$\equiv \left[ \left[ (k\Delta) \right] \cdot \triangleleft_{scatter} \cdot \oplus \right]$$

take care of the critics!  
(to implement the scheme)

$$\Delta_{MR} = \triangleleft_{scatter} \cdot \left[ \left[ (f) \right] \cdot (k\Delta) \right] \cdot \left[ \left[ \triangleleft_{scatter} \cdot \oplus \right] \right]_{mv}$$







HPC community  
190 algorithmic  
skeletons

2000

Software engineering

parallel design pattern

"recipes"

improve  
the efficiency  
of programmers

design patterns  
(Gamma book)

proxy facade factory

abstraction

layers

concurrency

algorithms

implementation structures

mechanisms

implementation details

— design spaces

↳ solves a generic  
problem  
&  
proposes recipes  
for that particular  
problem



