

SWWR

NUM:

Pros → Low static power

→ High density

cons → limited write endurance

Motiv:

→ Improve lifetime of NVM cells

→ Mitigate intra-set variation

Write variation types:

→ Inter-set : Some sets are used more than others.

→ Intra-set : Some blocks are used more than others.

Static Window Write Restriction (SWWR):

→ counters intra-set variations

→ divides cache into m windows. Each window has equal ways.

→ Issue: Very round robin window selection. Possibility of accumulation of multiple heavily written ways in the same window.

Algorithm:

1) Warmup: Run for I intervals like regular cache.

2) Select a window in a round robin fashion and

make it write restricted for I cycles.

The following can happen during this interval,

a) Read Hit: Usual

b) Write Hit but inside window:

case1: A empty/invalid line exists outside the window.

→ Redirect the write to that

→ Invalidate the block which is within the window.

(case2: No empty/invalid line exist outside the window).

→ Evict a block outside the window as per LRU.
and Insert there.

→ Invalidate the block which is within the window

c) Write Hit but outside window:

→ Usual

d) LLC Miss:

→ Newly arrived block is placed outside the window

Limitations :

→ Doesn't account for the writes in other window.

(Eg.)

Window → 1 2 3 4

Interval

1	WRW	light	light	Heavy
2	light	WRW	light	Heavy
3	light	light	WRW	Heavy

Because of round robin
it took 3 intervals
to make the most
overall used window
to be made WRW.

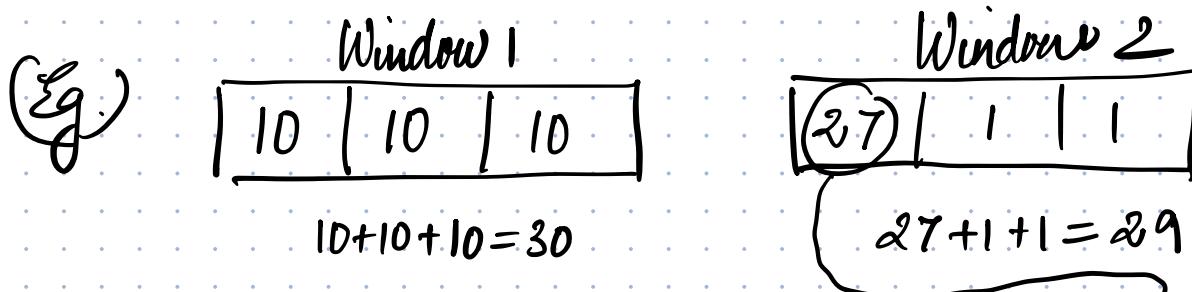
Solution \rightarrow DWWR : Dynamic Window Write Restriction

DWWR

- \rightarrow The algorithm is same as SWWR.
- \rightarrow But instead of round robin, each window has a counter.
- \rightarrow The WRW is chosen based on the max count.
- \rightarrow The counter of the WRW is reset.

Limitation :

- \rightarrow There can be heavily written ways inside a lightly written window.

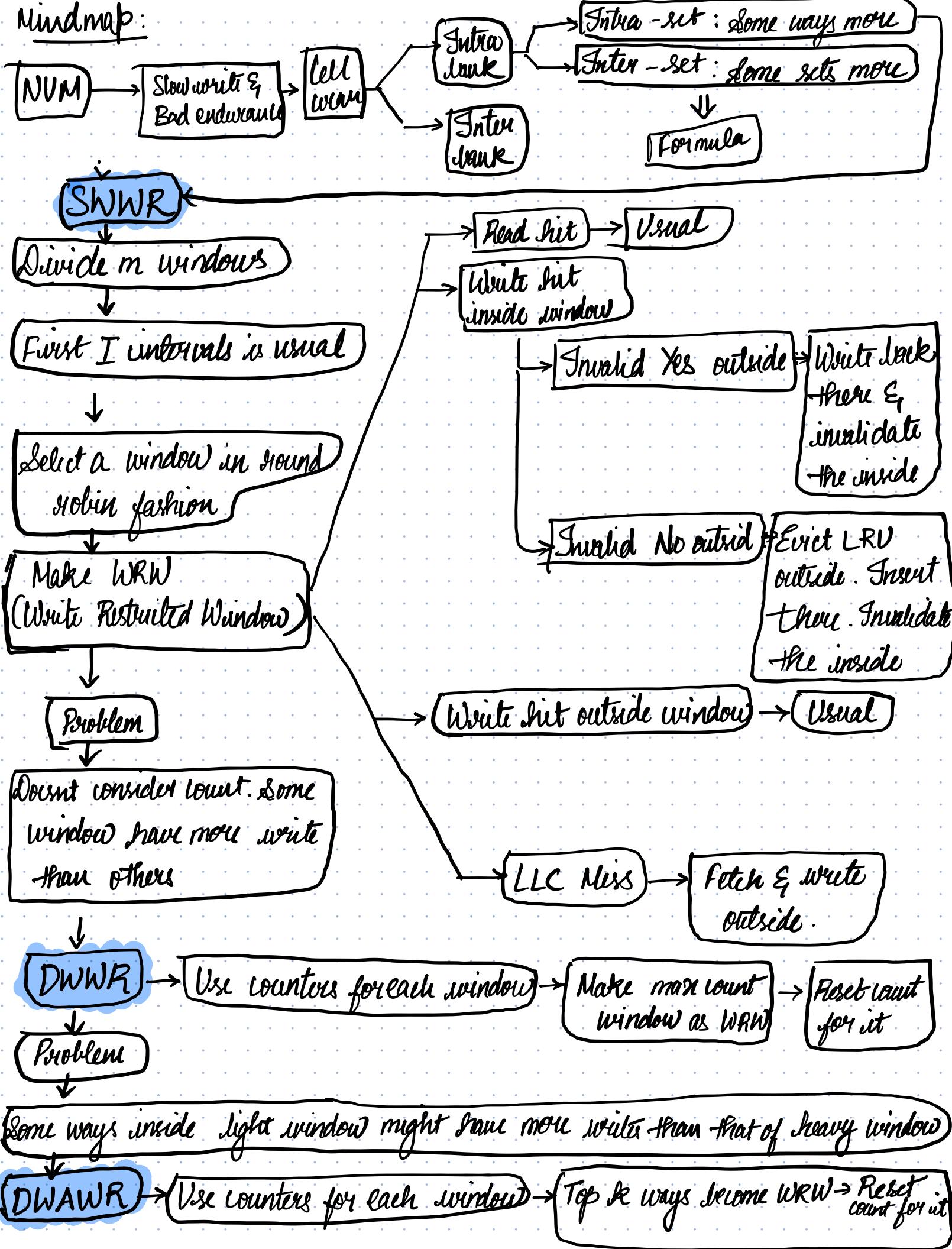


DWWR will choose Window 1 as WRW but this way has more writes than any other window.

Solution : DWAWR : Dynamic Way Aware Write Restriction

DWAWR

- \rightarrow Same as DWWR.
- \rightarrow But each way has a counter.
- \rightarrow the top n ways are selected as write restricted.
- \rightarrow Reset counters of the selected ways.



Write variations:

IntraV \Rightarrow Avg. deviation from the avg.

$$\text{IntraV} = \frac{1}{S. \text{Writeavg}} \sum_{k=1}^S \sqrt{\frac{\sum_{l=1}^A \left(W_{k,l} - \frac{\sum_{m=1}^A W_{k,m}}{A} \right)^2}{A-1}}$$

$$\text{InterV} = \frac{1}{\text{Writeavg}} \sqrt{\frac{\sum_{k=1}^S \left(\frac{\sum_{l=1}^A W_{k,l}}{A} - \text{Writeavg} \right)^2}{N-1}}$$

$$\text{Writeavg} = \frac{\sum_{k=1}^S \sum_{l=1}^A W_{k,l}}{S.A}$$

$$\text{Lifetime} = \frac{1}{\text{max write count on the block}}$$