RRIP

High Performance Cache Replacement using Re-Reference Interval Prediction(RRIP)

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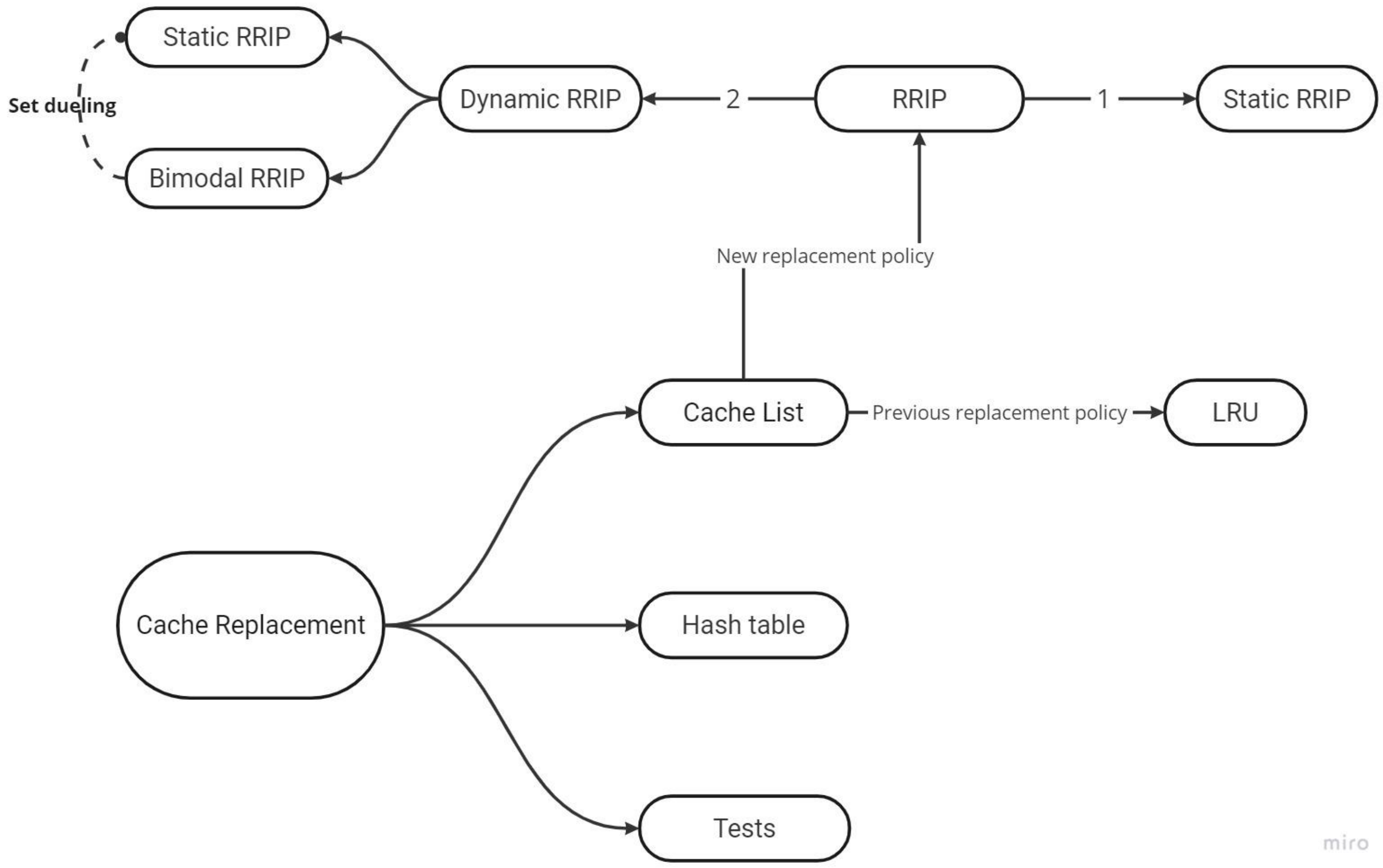

Static RRIP
Set dueling
Bimodal RRIP
Dynamic RRIP
2
RRIP
1
Static RRIP
New replacement policy
Cache List
Previous replacement policy
LRU
Cache Replacement
Hash table
Tests
miro

A List Node (the RRIP list is implemented using Doubly Linked List)

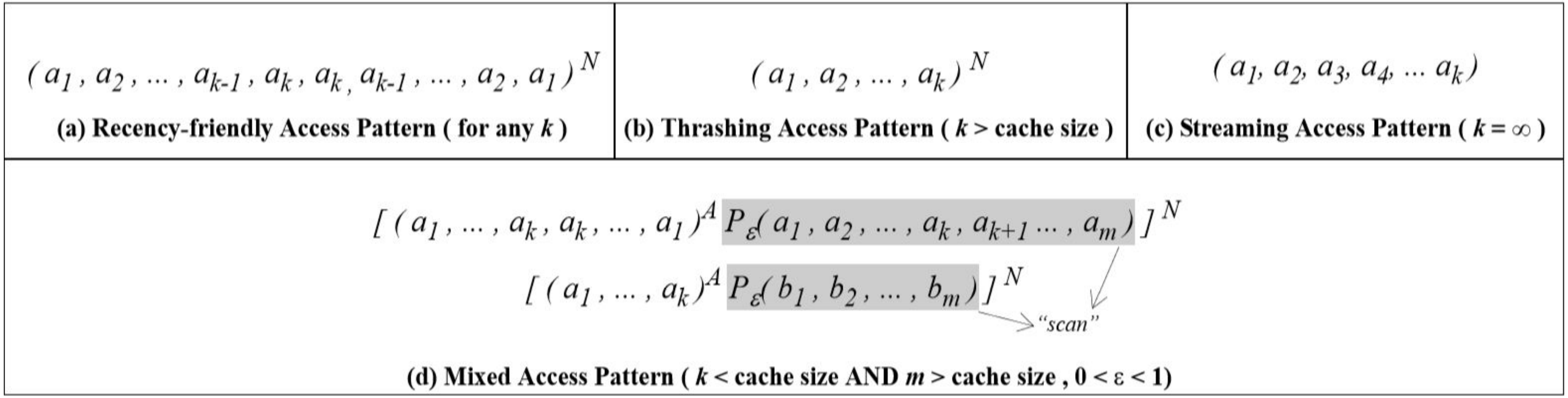
```
struct node_t {
    struct node_t *next, *prev;
    long data;      //the data stored in this Node
    unsigned value; //the RRIP value stored by a 2-bit
register per Node
};
```

RRPV of 0 represents a near-immediate re-reference interval of the cache block;

RRPV of 2 — a long re-reference interval;

RRPV of 3 — a distant re-reference interval.

Cache Access Patterns



$(a_1, a_2, \ldots, a_{k-1}, a_k, a_k, a_{k-1}, \ldots, a_2, a_1)^N$ **(a) Recency-friendly Access Pattern (for any *k*)**	$(a_1, a_2, \ldots, a_k)^N$ **(b) Thrashing Access Pattern (*k* > cache size)**	$(a_1, a_2, a_3, a_4, \ldots a_k)$ **(c) Streaming Access Pattern (*k* = ∞)**

$$[\,(a_1, \ldots, a_k, a_k, \ldots, a_1)^A\, \underbrace{P_\varepsilon(a_1, a_2, \ldots, a_k, a_{k+1} \ldots, a_m)}_{\text{“scan”}}\,]^N$$

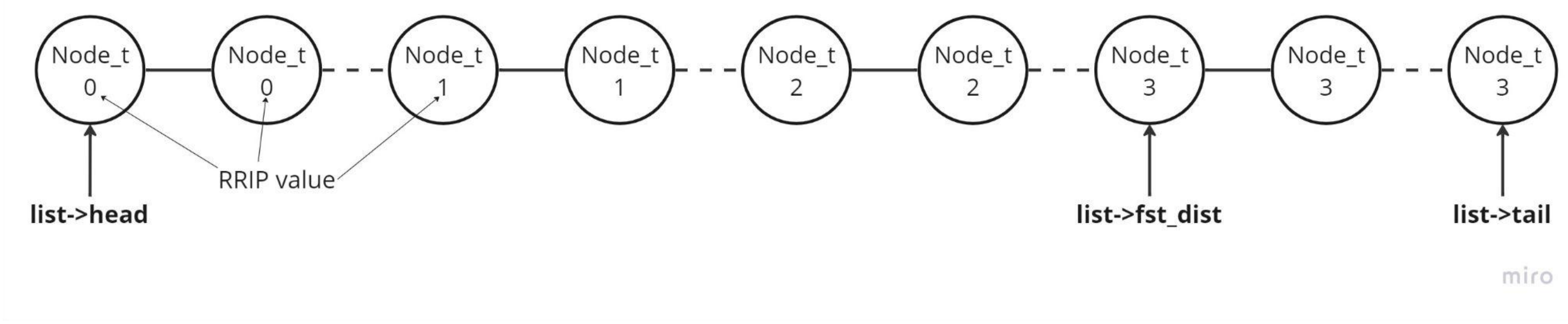
$$[\,(a_1, \ldots, a_k)^A\, \underbrace{P_\varepsilon(b_1, b_2, \ldots, b_m)}_{\text{“scan”}}\,]^N$$

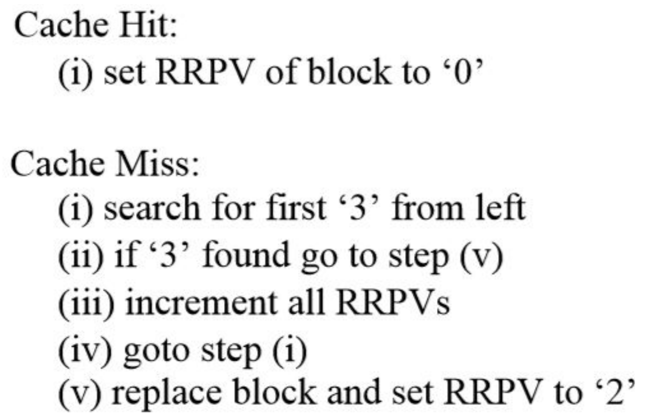
(d) Mixed Access Pattern (*k* < cache size AND *m* > cache size , $0 < \varepsilon < 1$)

In general, for associativity A, active working set size w ($w < A$), and scan length S_{len}, M-bit SRRIP is scan-resistant when

$$S_{len} <= (2^M - 1) * (A - w) \qquad \text{(Eq. 1)}$$

A List (a collection of Nodes in ascending order according to their RRIP)



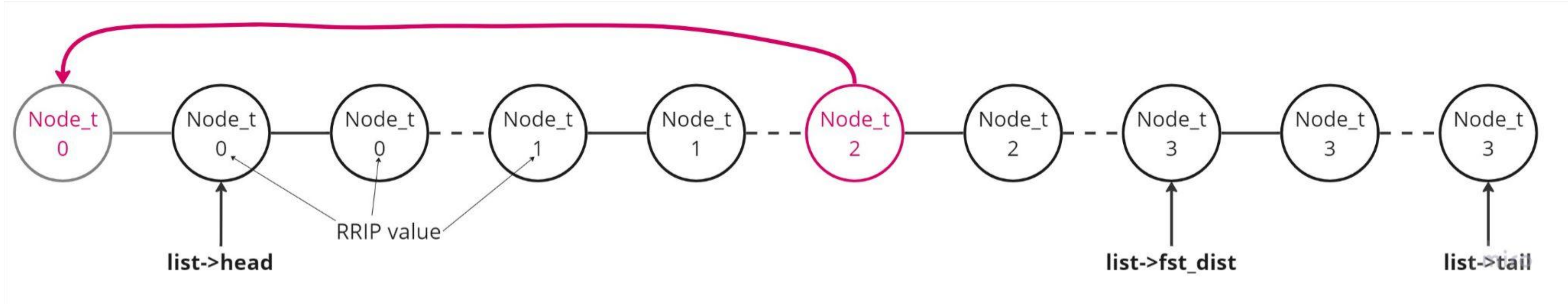


```
Cache Hit:
    (i) set RRPV of block to '0'

Cache Miss:
    (i) search for first '3' from left
    (ii) if '3' found go to step (v)
    (iii) increment all RRPVs
    (iv) goto step (i)
    (v) replace block and set RRPV to '2'
```

The RRIP replacement policy

A List (a collection of Nodes in ascending order according to their RRIP)



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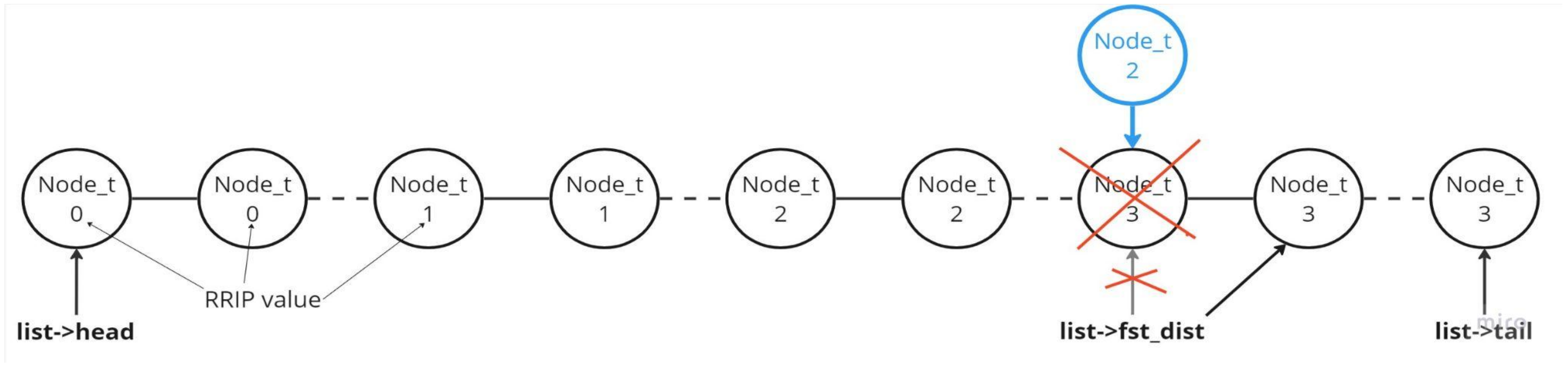
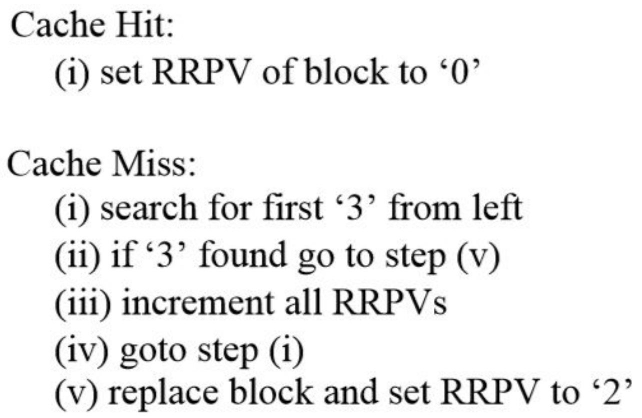
(v) replace block and set RRPV to ‘2’

The RRIP replacement policy

A List (a collection of Nodes in ascending order according to their RRIP)

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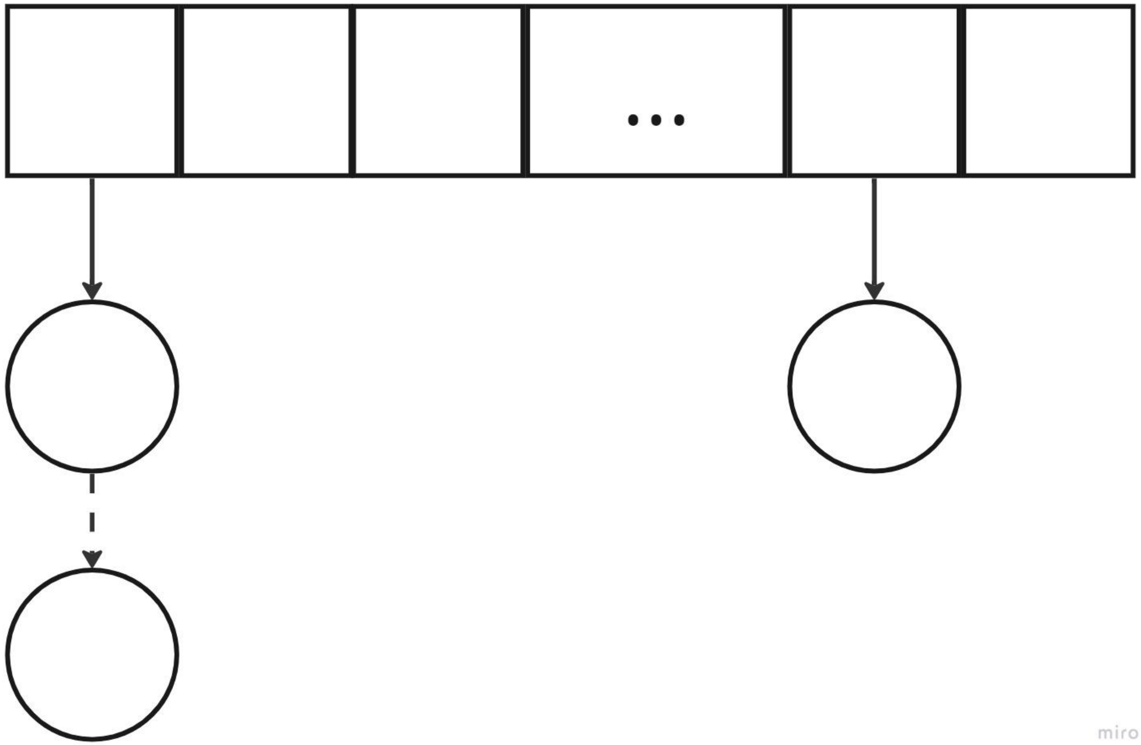
The RRIP replacement policy

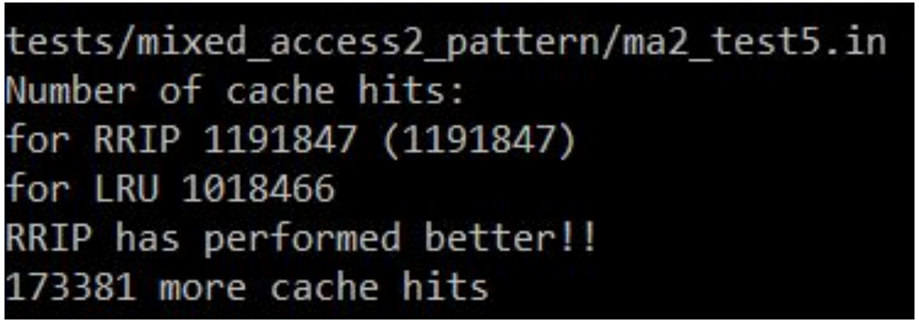
Hash table



Comparison of efficiency

☺️with LRU
☺️with RRIP that is implemented by simple hash(an array of double pointers)

Example:



```
tests/mixed_access2_pattern/ma2_test5.in
Number of cache hits:
for RRIP 1191847 (1191847)
for LRU 1018466
RRIP has performed better!!
173381 more cache hits
```

TODO: DRRIP replacement policy

SRRIP is scan-resistant.
DRRIP is scan-resistant and thrash-resistant.

(under construction)