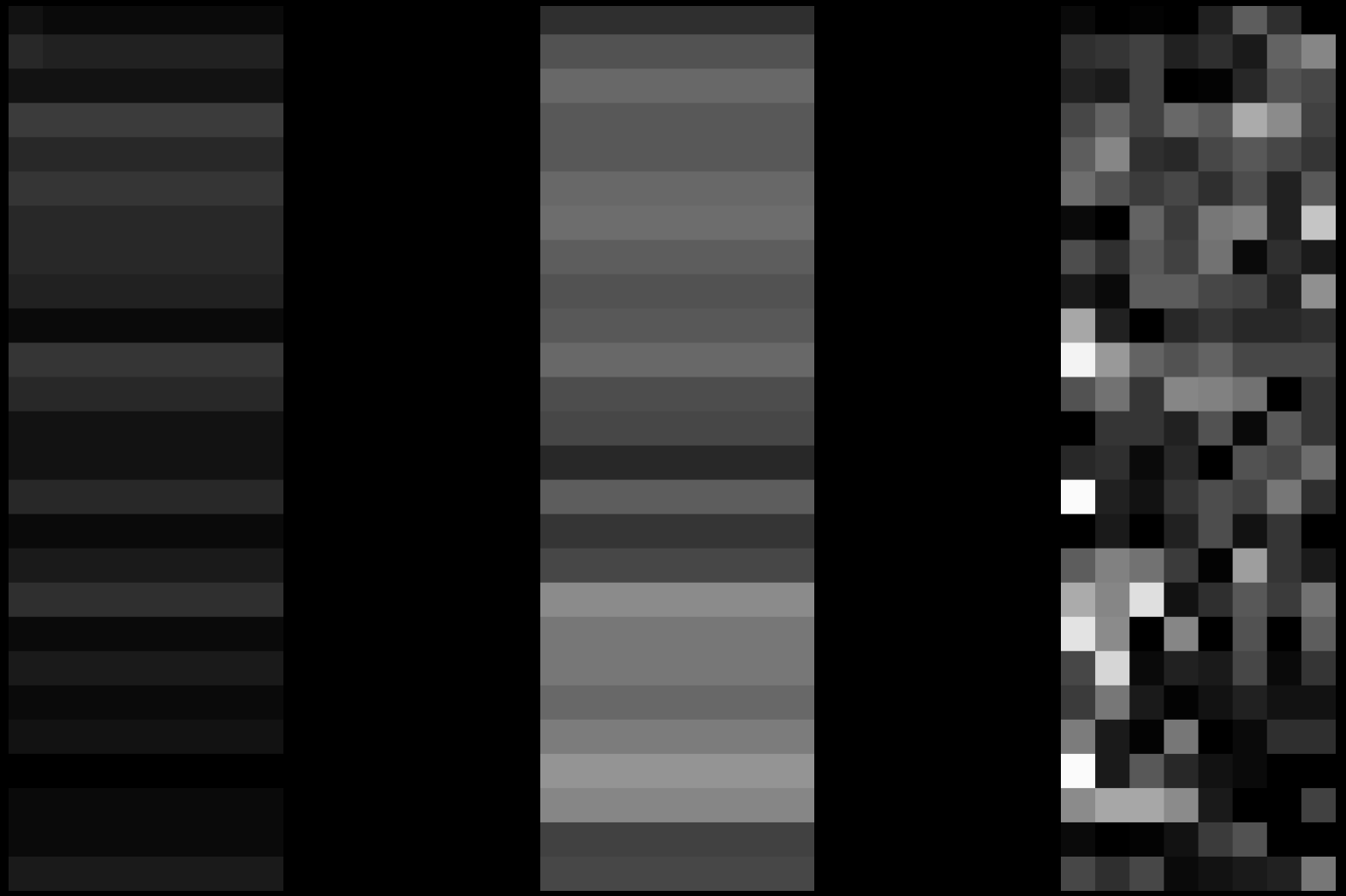
EXPLORING PREDICTIVE REPLACEMENT POLICIES FOR INSTRUCTION CACHE AND BRANCH TARGET BUFFER



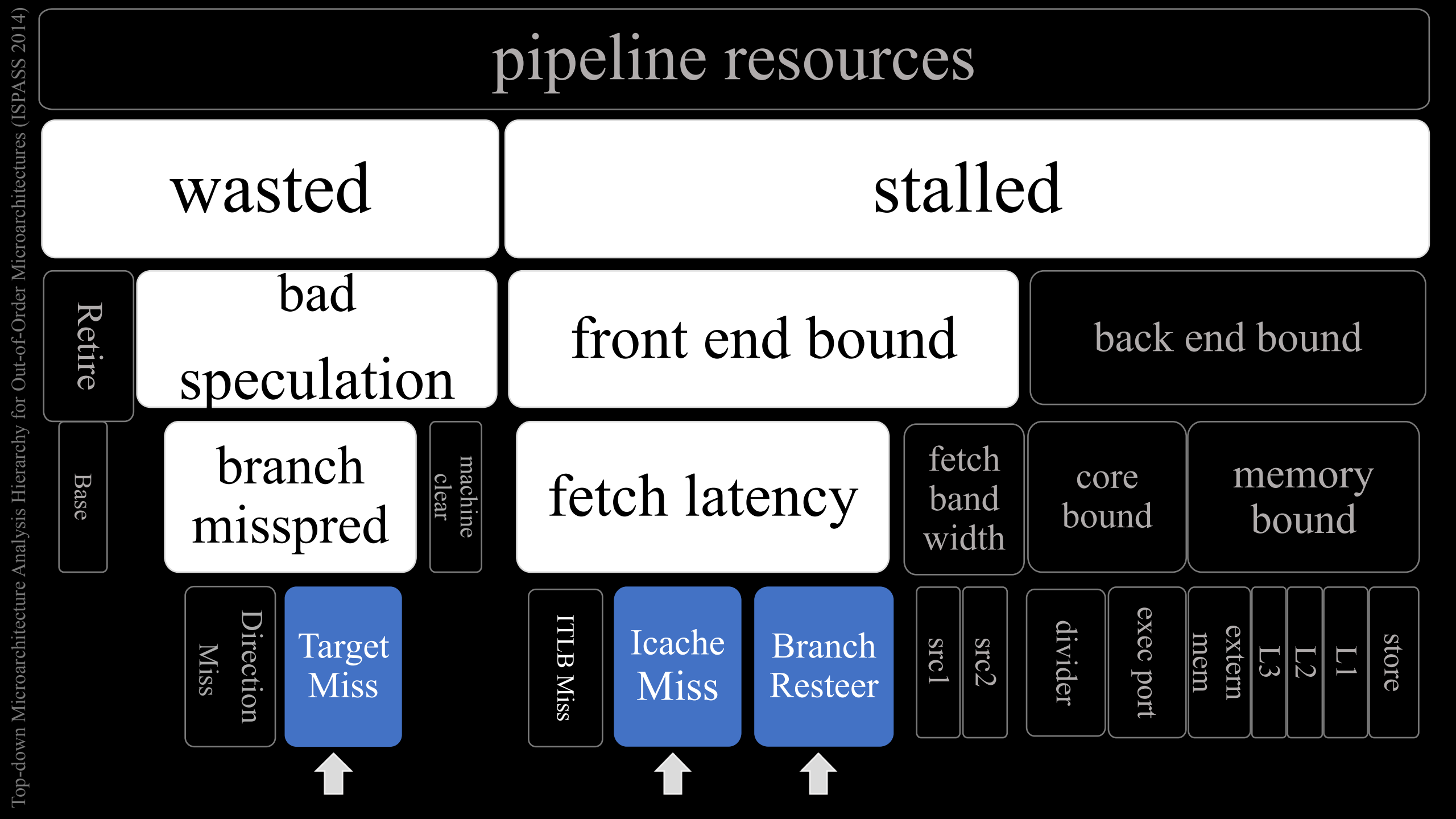
Samira Mirbagher Ajorpaz
Elba Garza
Sangam Jindal
Daniel A. Jiménez

COMPUTER SCIENCE & ENGINEERING
TEXAS A&M UNIVERSITY

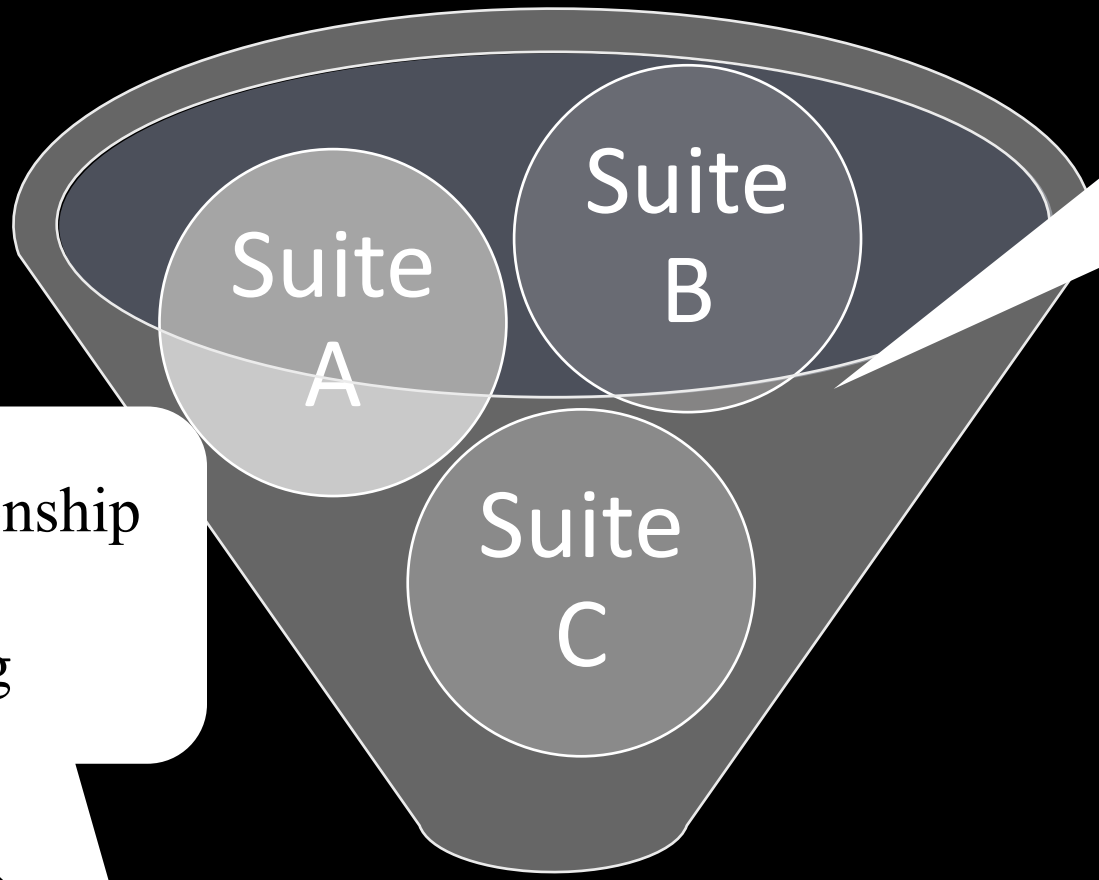
Traditional replacement policies cannot address the problem of dead blocks



LRU Rand SRRIP



Top-down Microarchitecture Analysis Hierarchy for Out-of-Order Microarchitectures (ISPASS 2014)

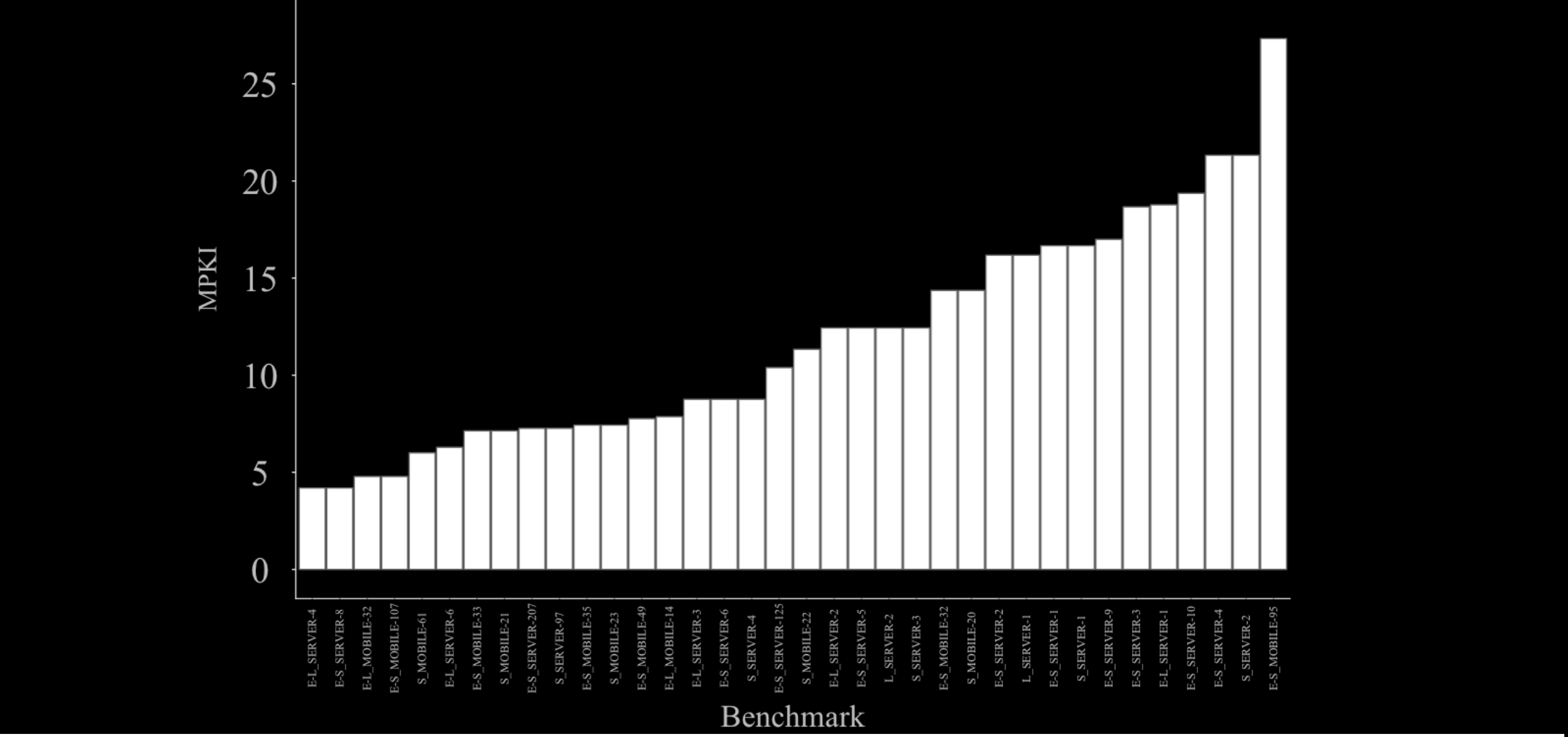


Thousands of workloads from popular benchmark suites

Part of fifth Championship Branch Prediction, provided by Samsung

223 training

+ 439 evaluation workload

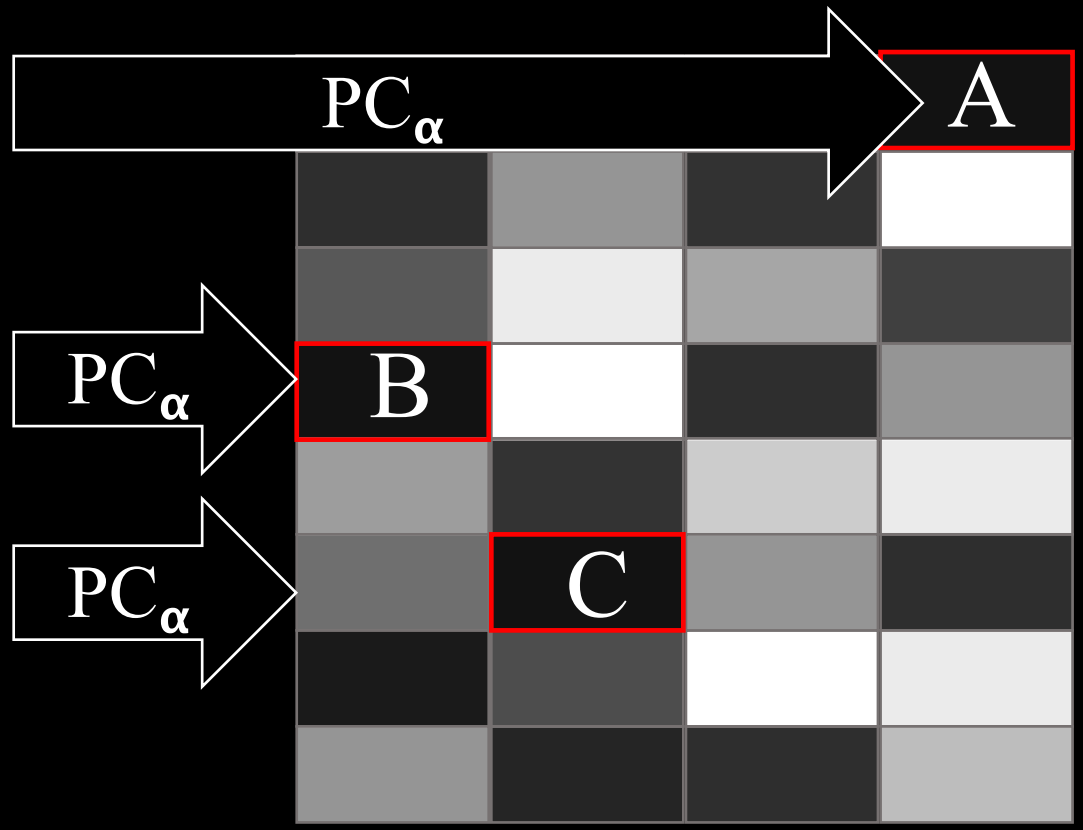


Many applications have
significant I-cache and BTB misses

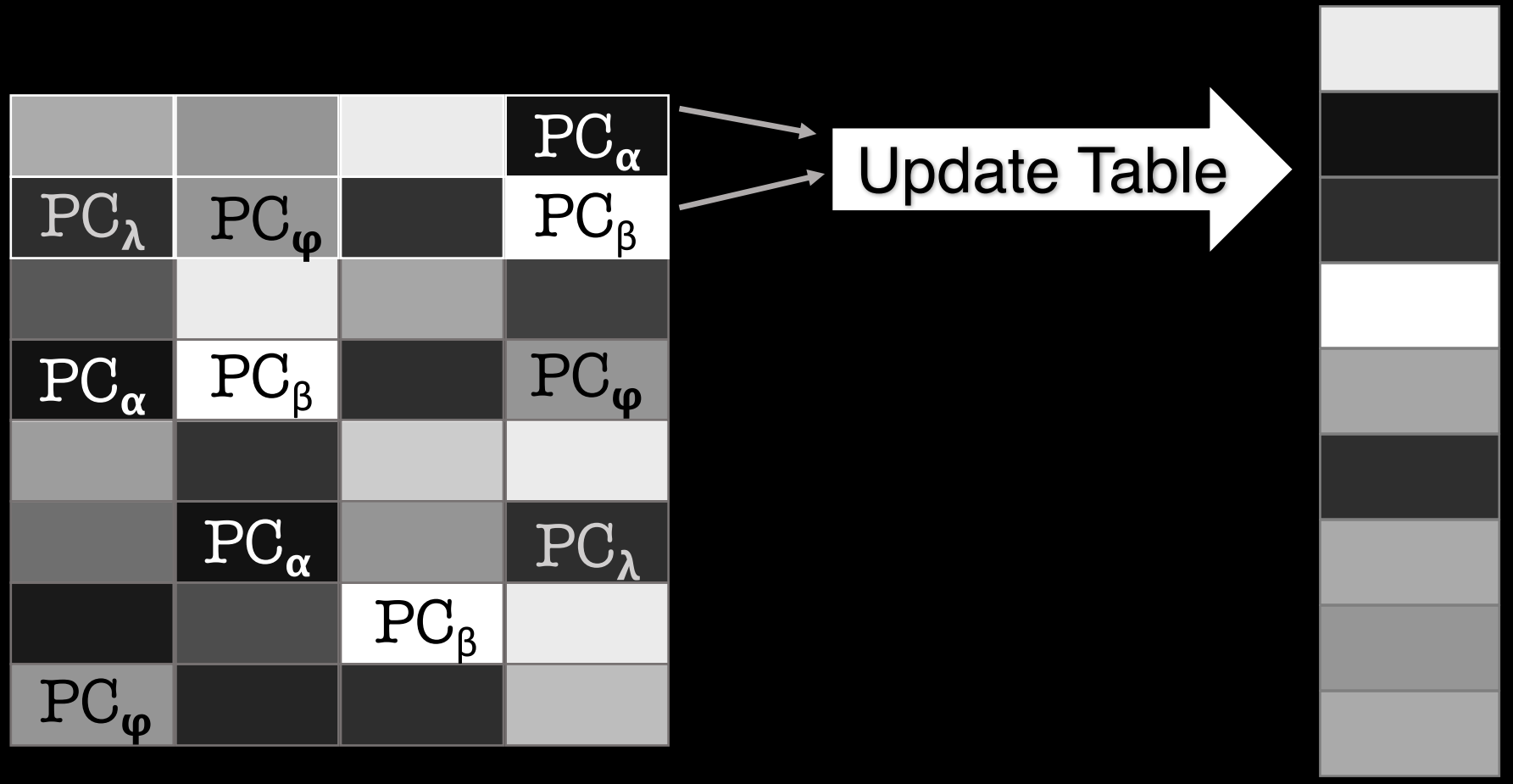
No previous work has explored
Predictive Replacement Policies for I-cache and BTB

If A becomes dead,

B and C are likely to become dead too.



Sampling Dead Block Prediction learns from a small number of sets



Sampling Dead Block Prediction reduces many dead blocks in LL data cache

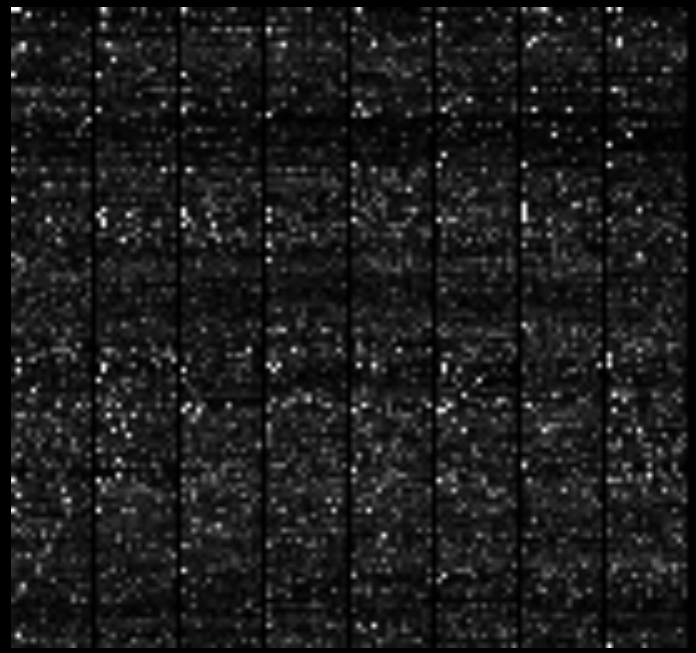
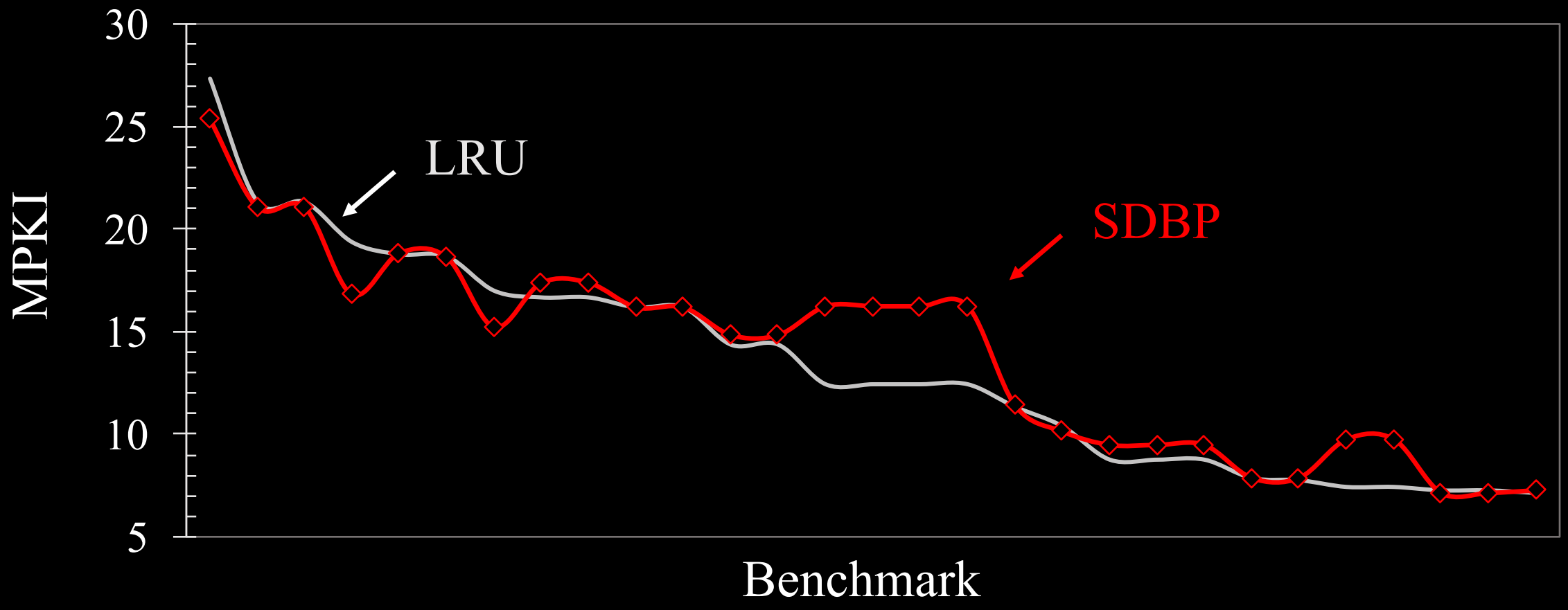


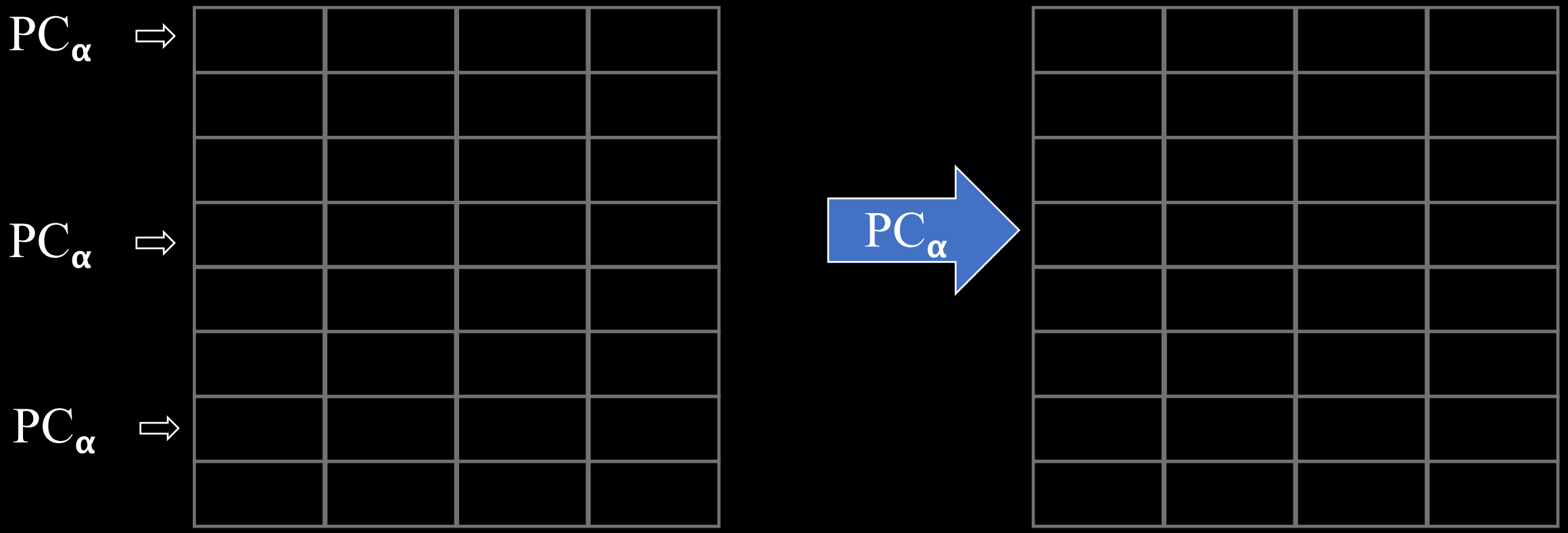


Photo Credit: Sampling Dead Block Predictor by Khan *et al.*



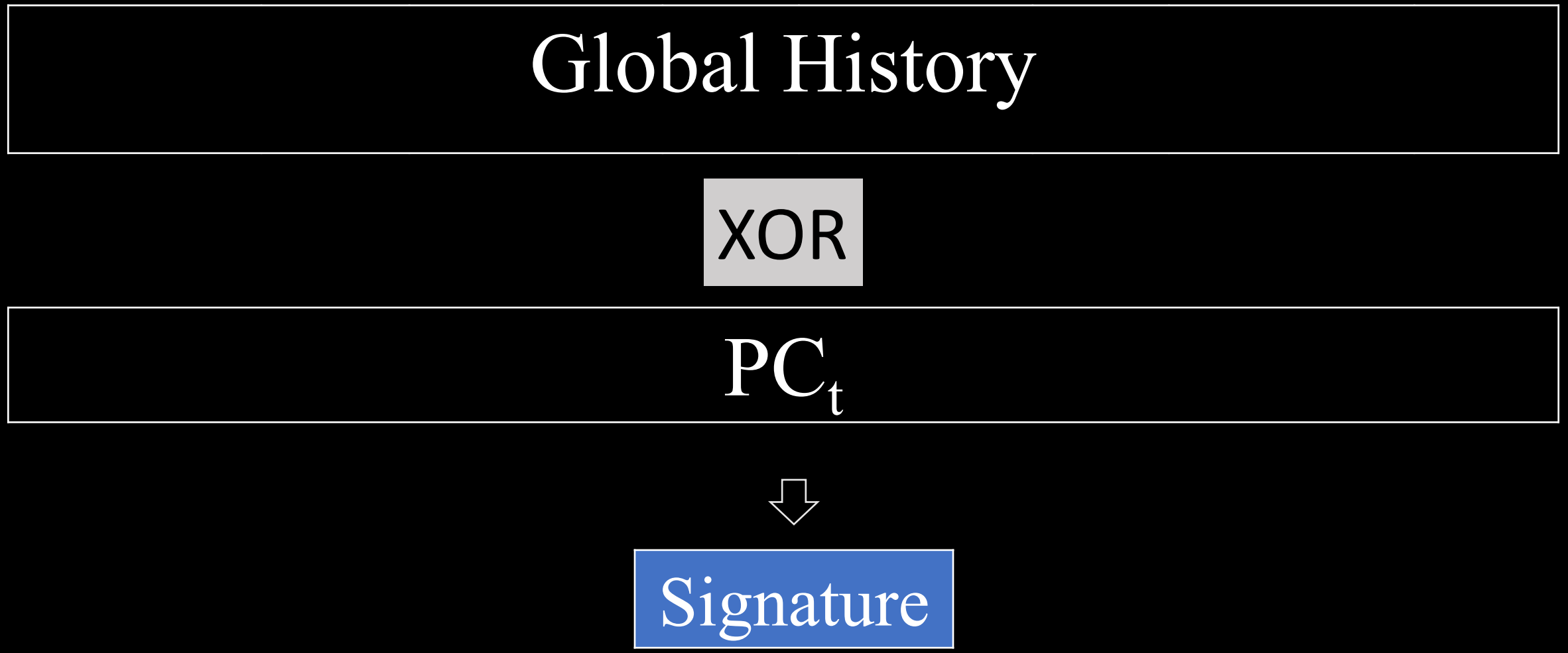
SDBP increase I-cache MPKI by 4% in average

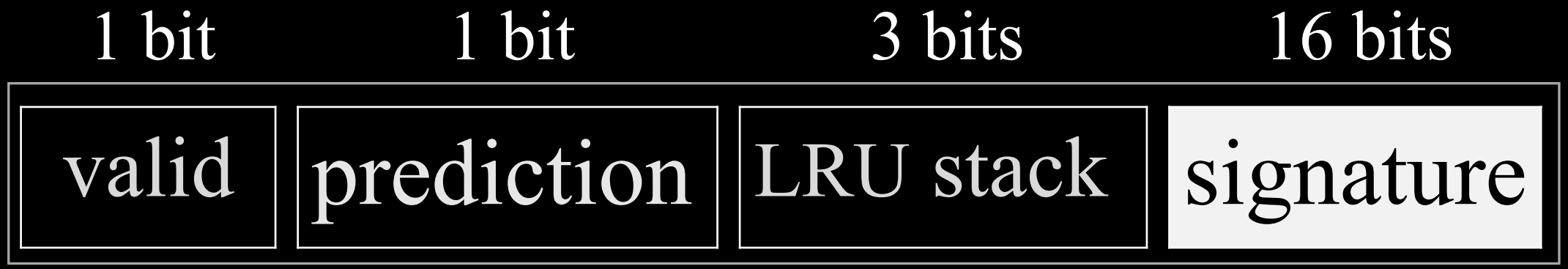
In I-cache or BTB, one PC accesses only one set



GHRP

GHRP correlates Reuse behavior with control flow History





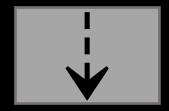
Extra information kept in I-cache block

GHRP prediction
is done by
tracking the behavior
using the signature



Eviction

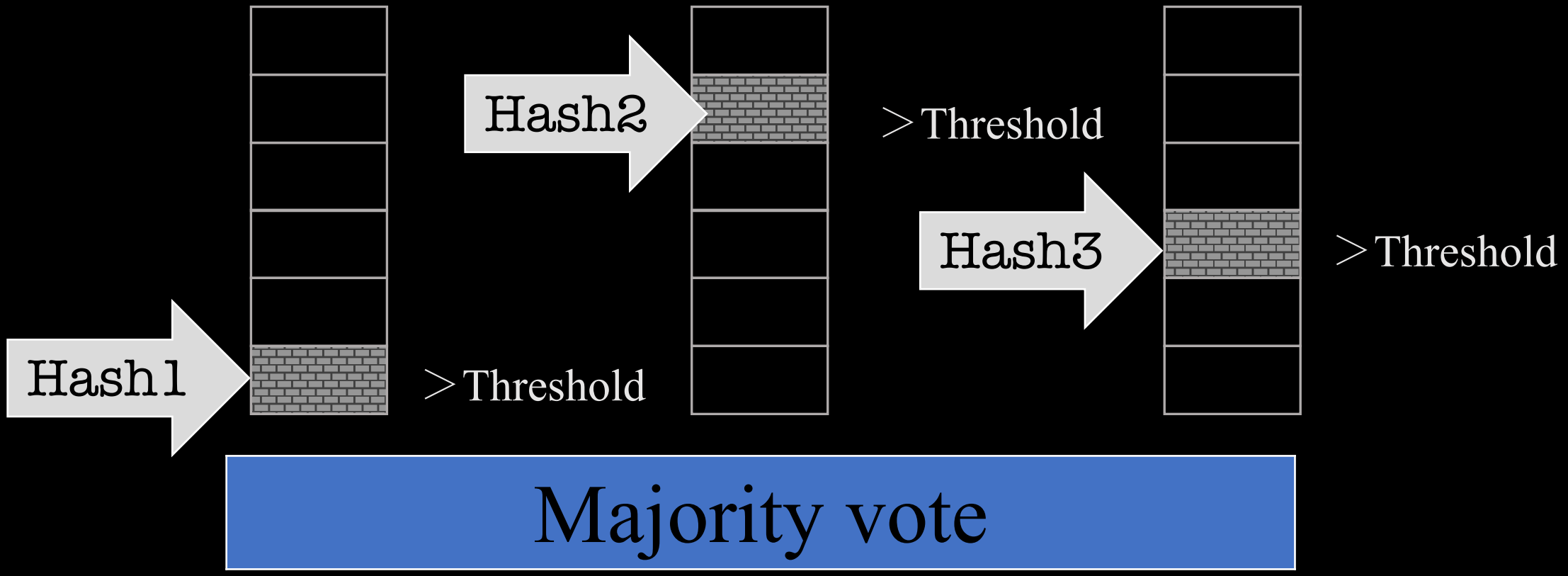
Reuse





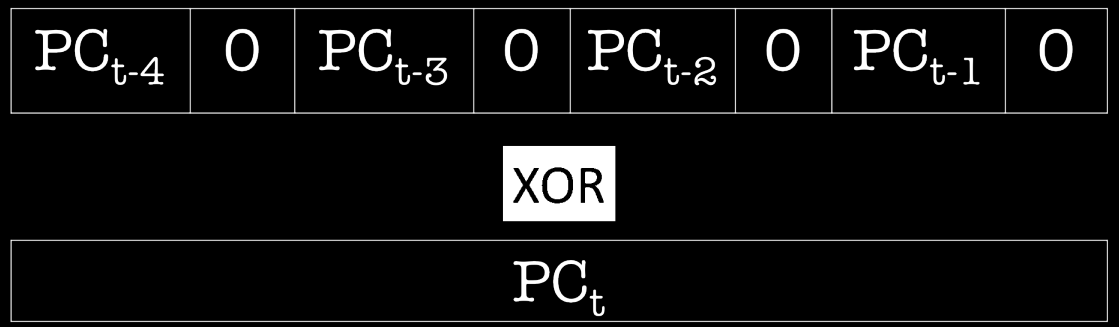
Extra information kept in I-cache block

Majority vote is required for GHRP decisions

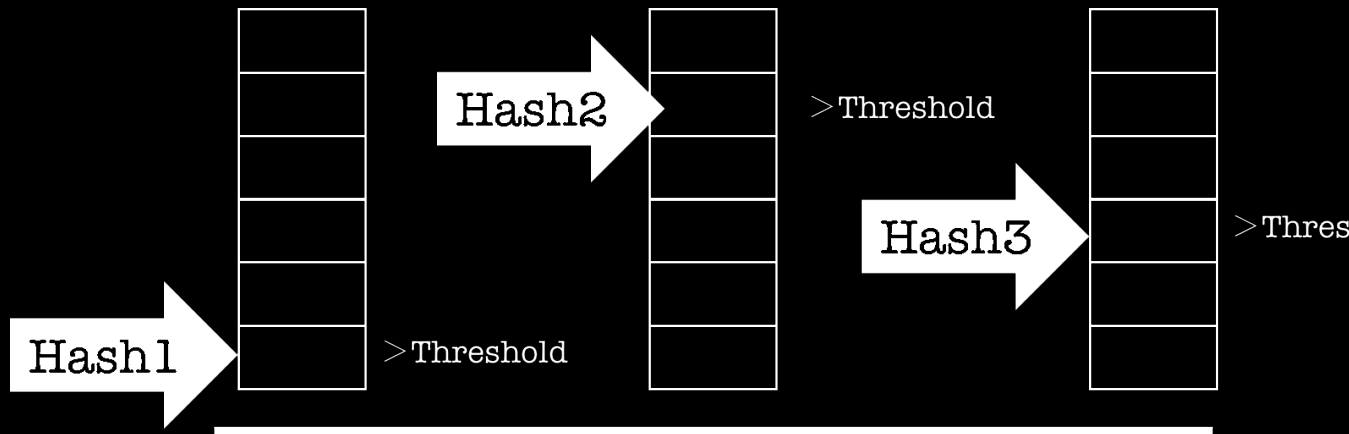


⇩

Prediction



New Signature



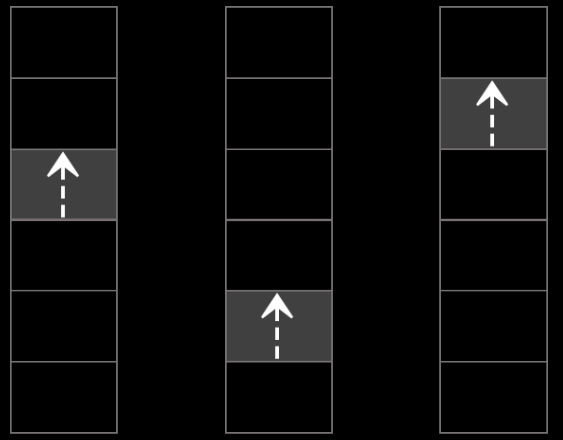
Majority vote

Bypass

New Prediction



Victim Block



Eviction

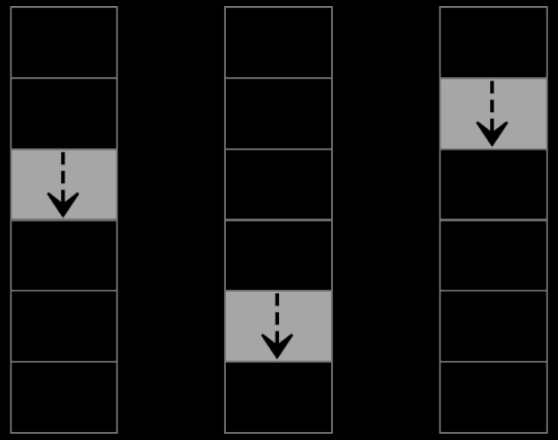


New Block

Miss
Not Bypass

valid	prediction	LRU stack	signature

Hit Block

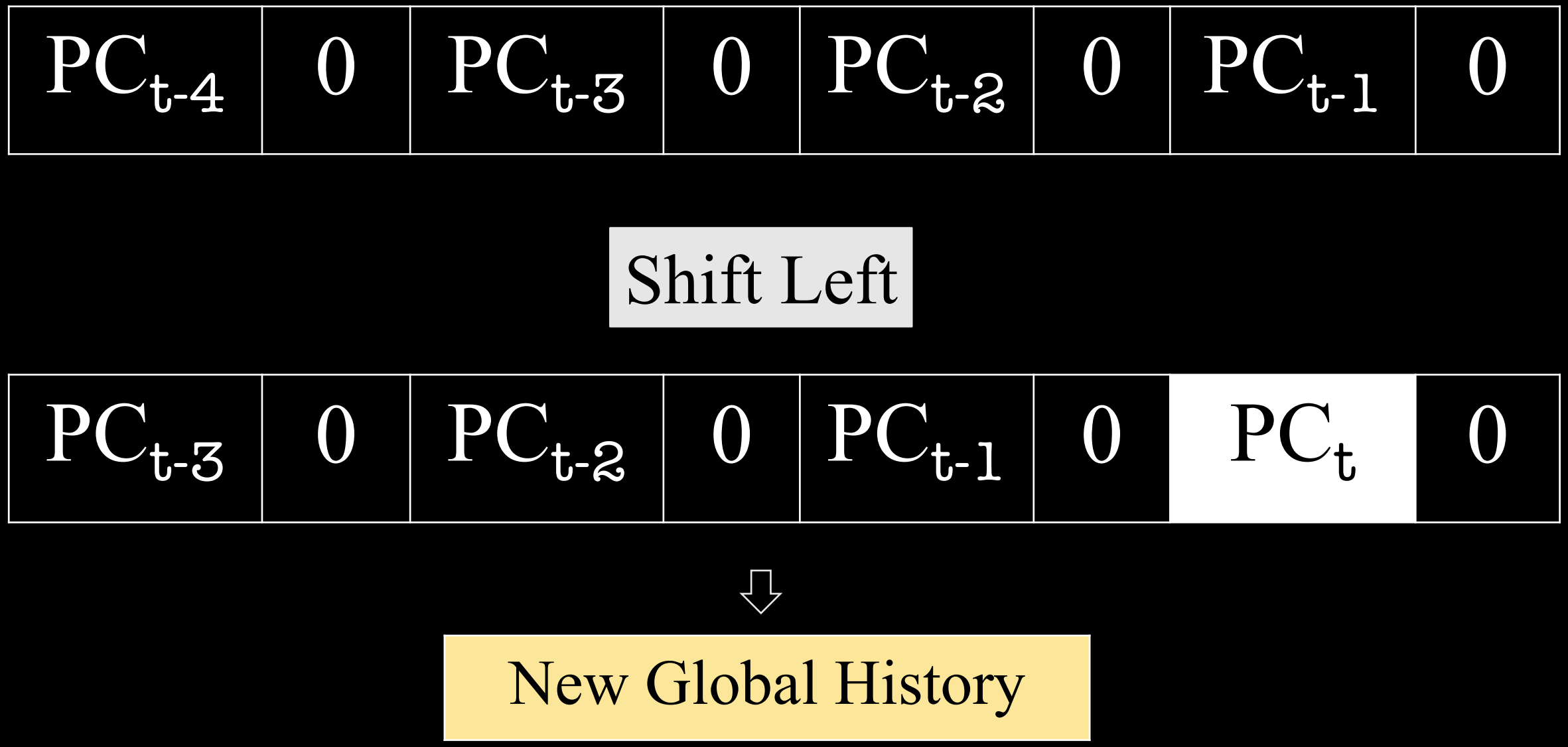


Reuse

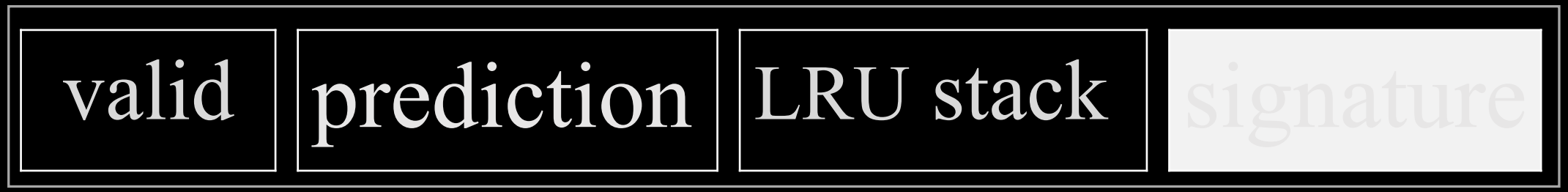
valid	prediction	LRU stack	signature

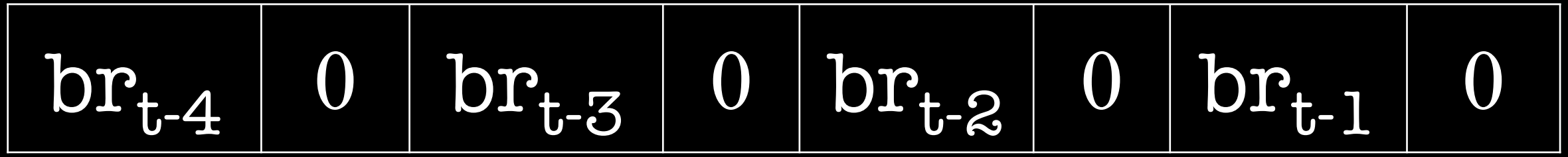
Hit

Hit Block


PC_{t-4}
0
PC_{t-3}
0
PC_{t-2}
0
PC_{t-1}
0
Shift Left
PC_{t-3}
0
PC_{t-2}
0
PC_{t-1}
0
PC_t
0
New Global History

BTB and I-cache
can share
Prediction Tables and History Register





Simulator
CBP5
Trace driven
MPKI

Branch Prediction
Hashed Perceptron

Workloads
662 traces
Short-Mobile, Long-Mobile, Short-Server, Long-Server
CBP5, Samsung

Comparison
LRU(baseline)
Random
SRRIP
SDBP

I-cache
64KB
8 Way
64B

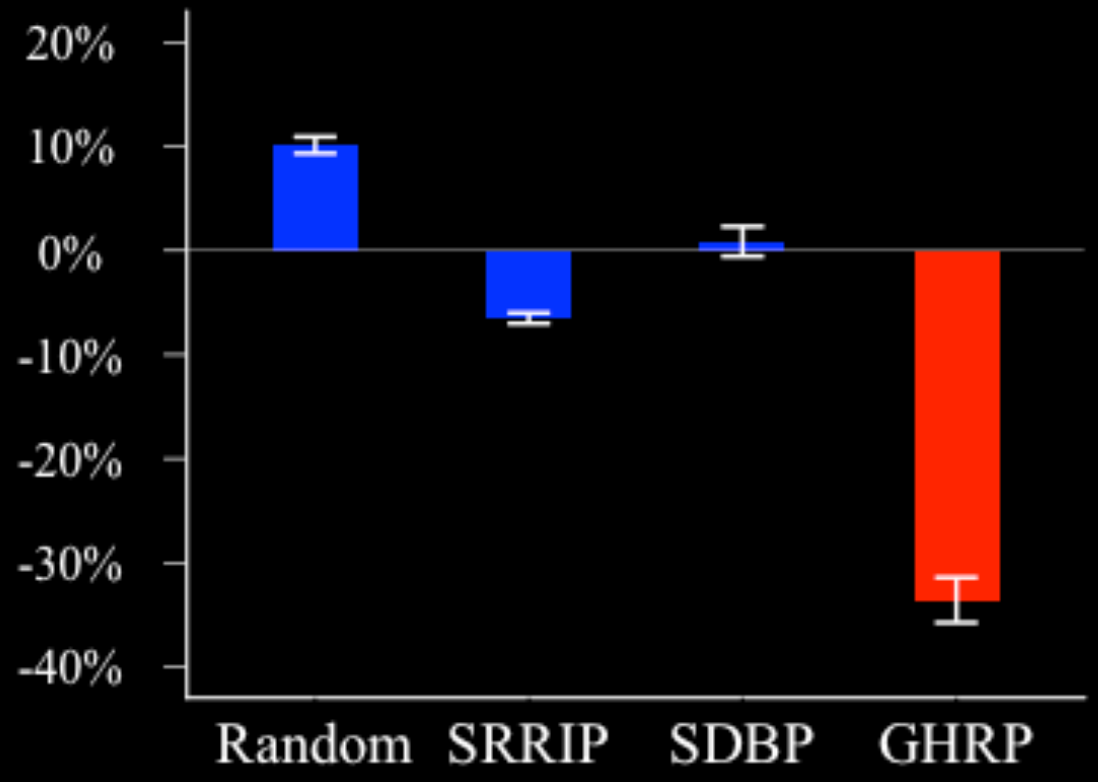
BTB
4K Entry
8 Way

Storage overhead GHRP for 64KB, 8-way I-cache with 64B blocks

2 bit counters	16 bits	1 bit	16 bits
4,096 entries	1,024 blocks	1,024 blocks	One register
Three tables			
Prediction Tables 3KB	Signature bits 2KB	Prediction bits 128B	History Register 2B

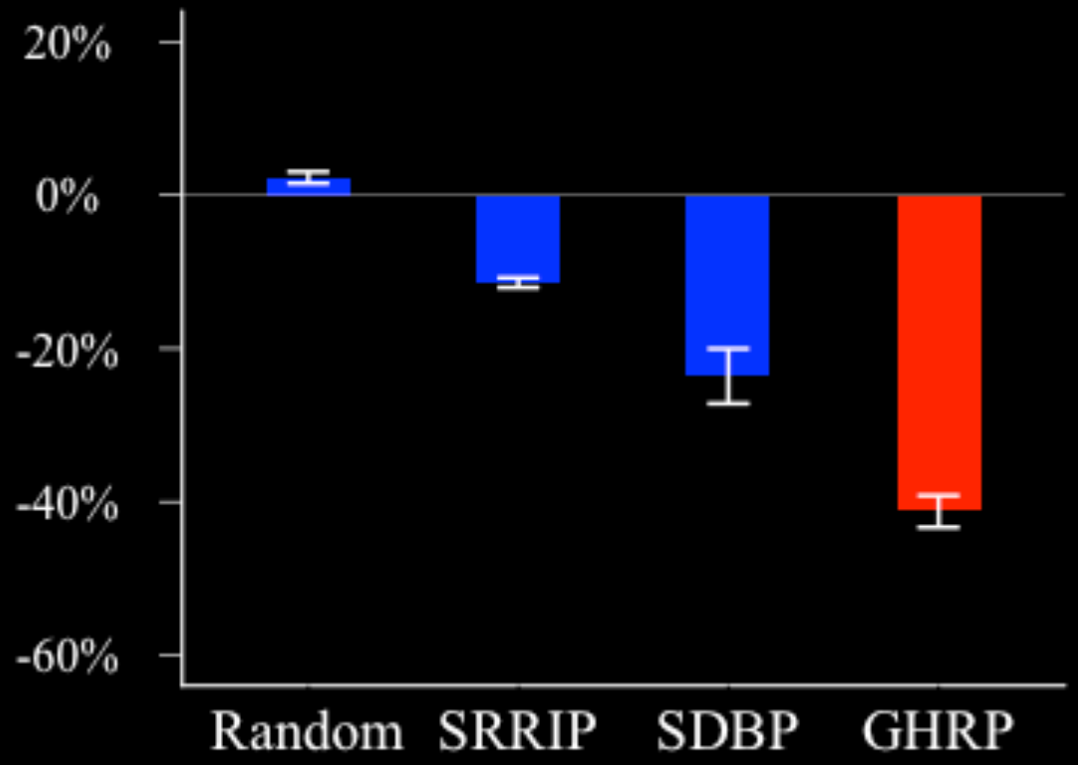
Total is 5.13KB or
8% of the capacity of the I-cache

I-cache MPKI reduction relative to LRU

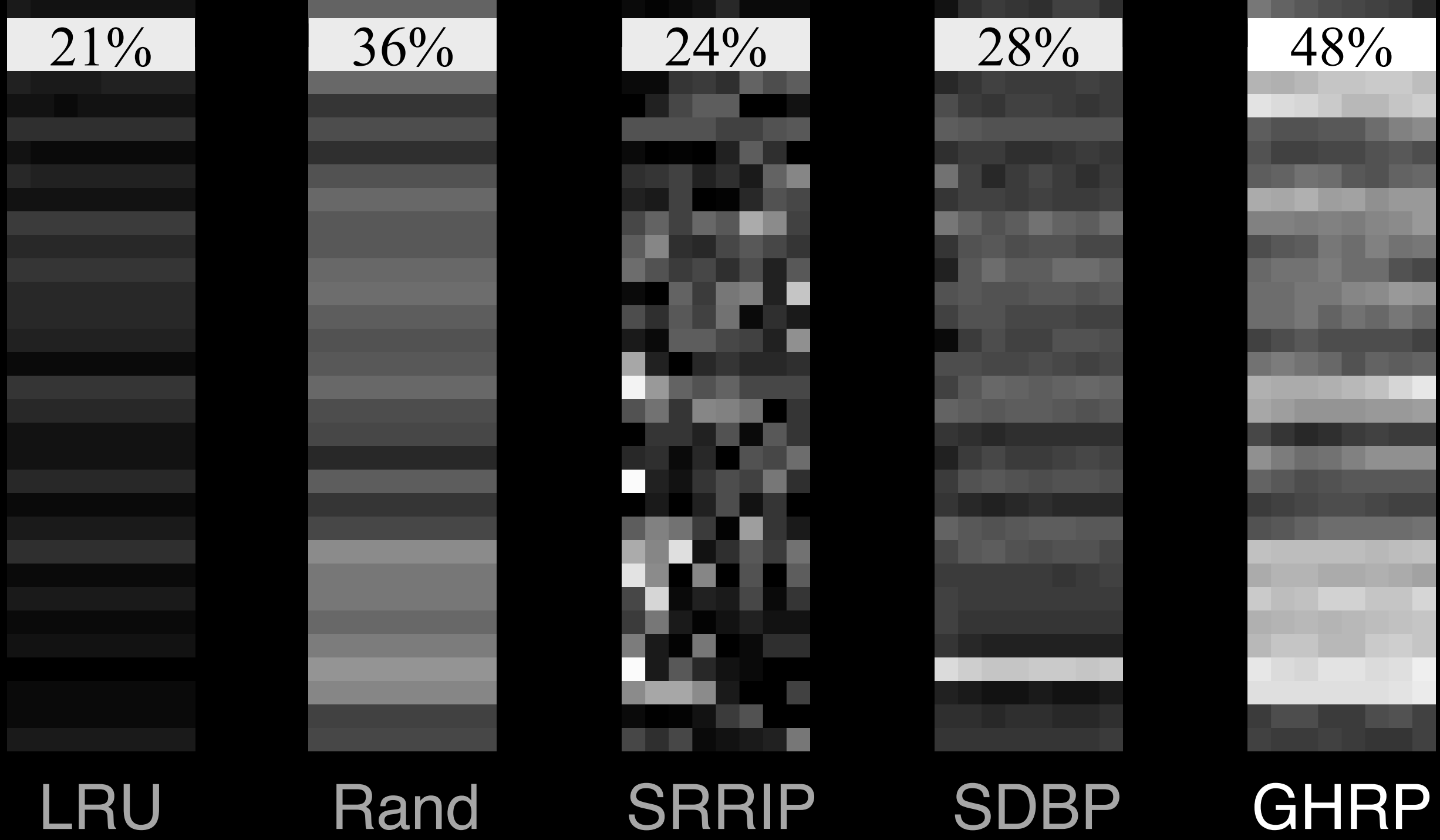


With 95% certainty GHRP reduces I-cache MPKI by 33% compared to LRU

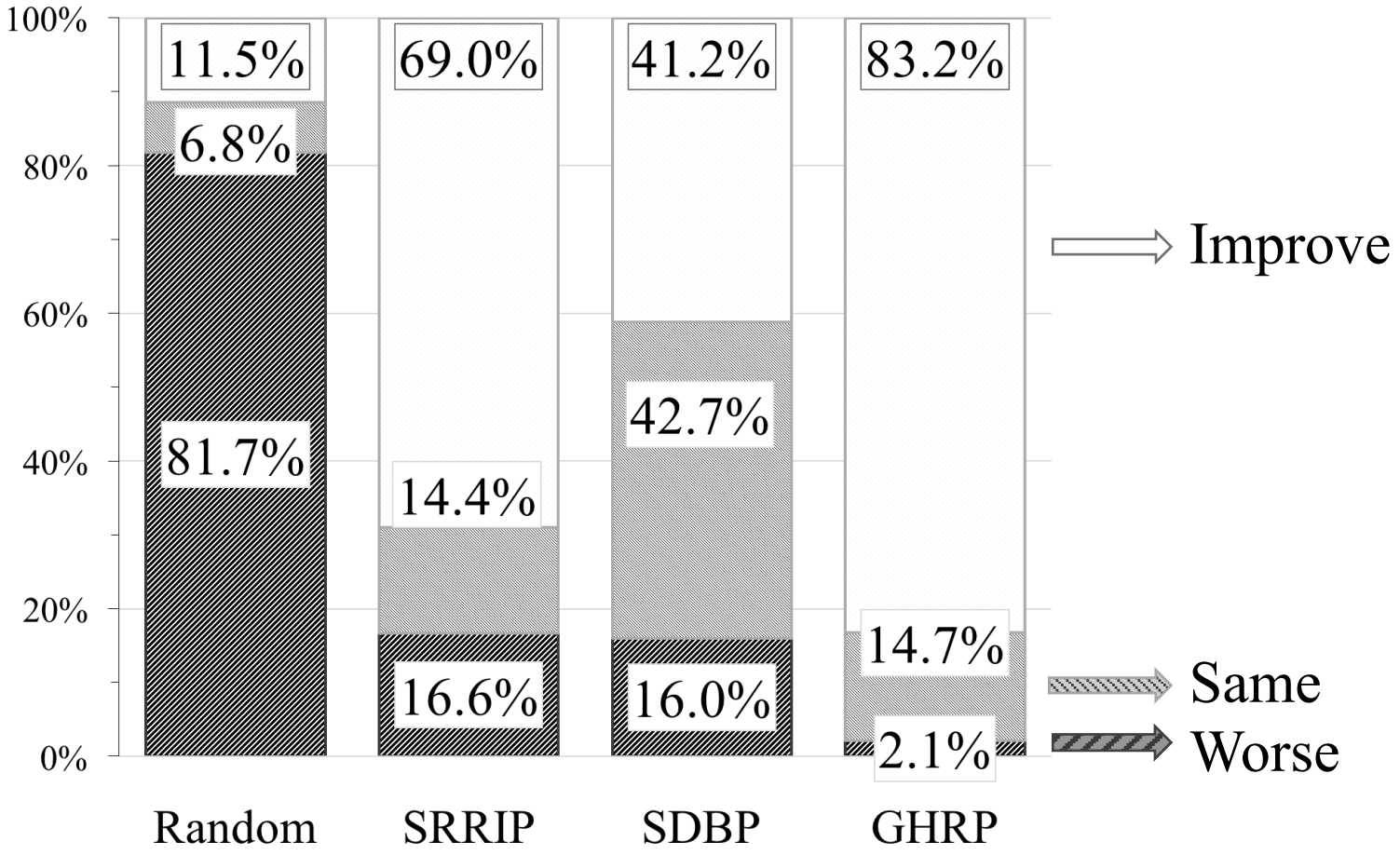
BTB MPKI reduction relative to LRU



With 95% certainty GHRP reduces BTB MPKI by 41% compared to LRU


21%
36%
24%
28%
48%
LRU
Rand
SRRIP
SDBP
GHRP

In summary, predictive replacement policies can significantly improve I-cache and BTB efficiency



Questions?