Project Report on Last Level Cache Simulator

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Introduction:

A cache is a hardware or software mechanism that stores data, enabling quicker access to frequently requested information. This data may originate from prior computations or be a duplicate of data stored elsewhere. When the needed data is found in the cache, it is termed a cache hit; if it is unavailable, it is called a cache miss. A higher cache hit rate enhances system performance, as retrieving data from the cache is significantly faster than recalculating it or accessing slower storage mediums.

Design Specifications:

The following specifications are used to implement the Last Level Cache:

- Cache byte Line: 64 - byte
- Total capacity: 16MB
- Associativity: 16 - way
- Coherence Protocol: MESI
- Page Replacement Policy: Pseudo-LRU
- Write decision policy: Write back
- Write Miss Decision policy: Write allocate

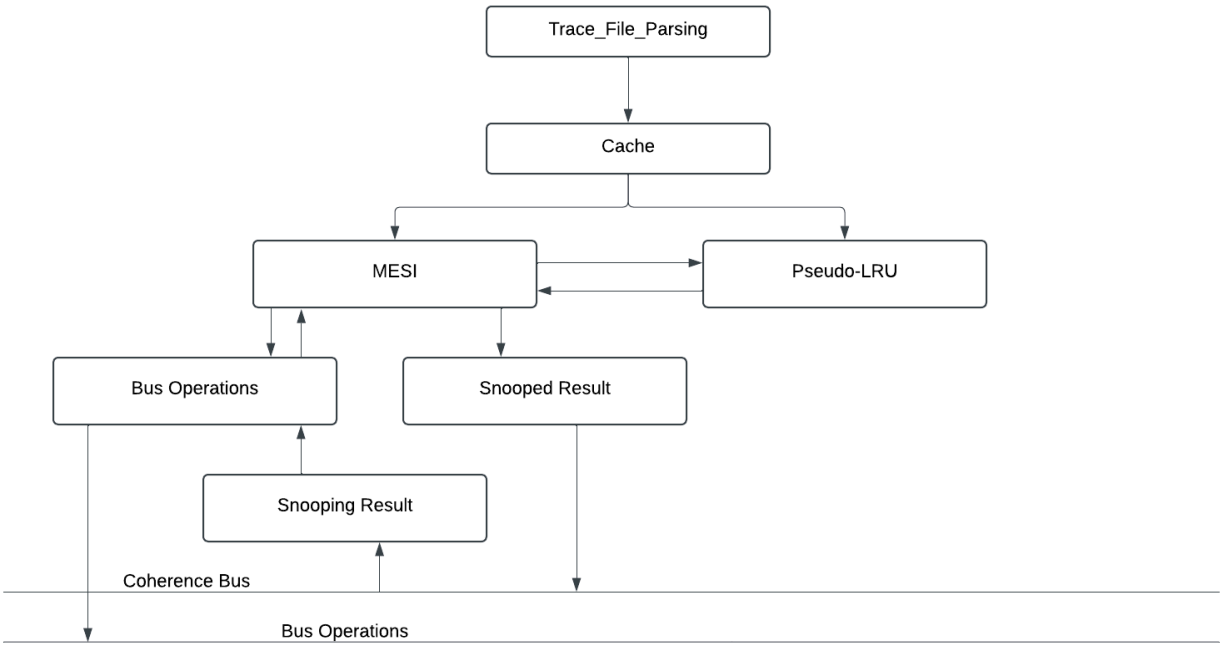
The following specifications are considered for the implementation of Higher level cache:

- Cache Byte Line: 64 - byte
- Write decision policy: Write through(once),
  Write back
- Associativity: 4 - way

Assumptions:

- Single Byte addressable mode is used for write and read references.
- The CPU address is 32 bit wide

Design Architecture:



Source code modules:

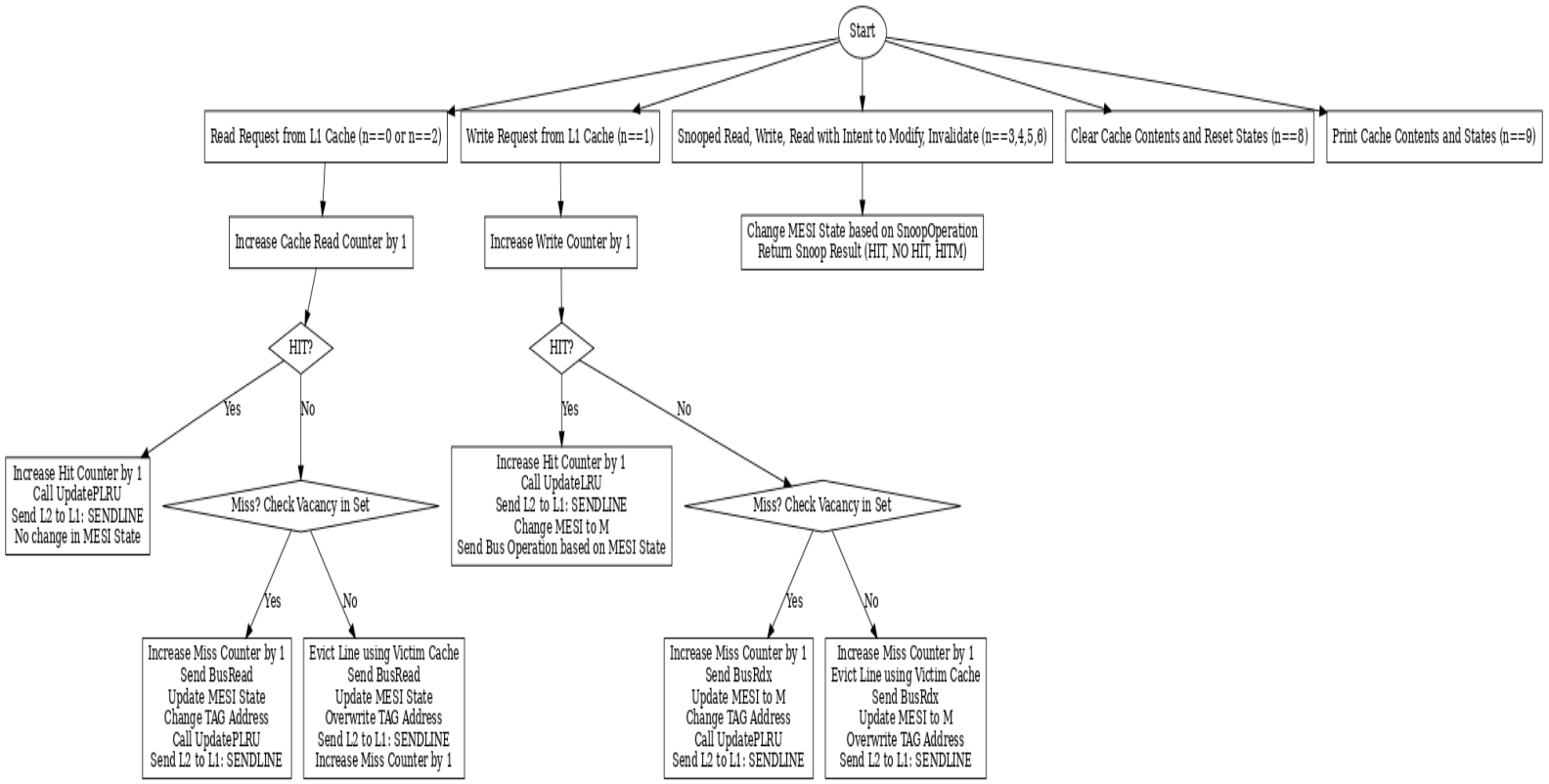
The following files are used in our project:
cache_define.sv: The package file where all the variables are parameterized and have global scope.
cache_design.sv: The main design file which performs all the operations read from the trace file.

Applications:

Caches are utilized in several ways:

- In GPUs and DSPs, caches are organized hierarchically to optimize performance.
- For translating virtual memory addresses to physical memory addresses, a specialized memory cache known as the Translation Lookaside Buffer (TLB) is used.
- Browsers maintain a cache to store data from previous browsing sessions, allowing faster access during future visits.

Execution Flow Chart



CACHE READ/WRITES

0 0BADBAD0

1 1BADBAD0

0 2BADBAD0

1 3BADBAD0

0 4BADBAD0

1 5BADBAD0

0 6BADBAD0

1 7BADBAD0

0 8BADBAD0

1 9BADBAD0

0 ABADBAD0

1 BBADBAD0

0 CBADBAD0

1 DBADBAD0

0 EBADBAD0

1 FBADBAD0

1 1BADBAD0

0 DBADBAD0

0 EBADBAD0

1 8BADBAD0

9

Generated Output:

```
# RUNNING IN SILENT MODE
# Using specified file: test.txt
# Valid Lines in LLC:
#
# MESI    |    TAG    |          SET       |    WAY    |
# ----------------------------------------------------
#  S       |    0ba    |        14059     |        0    |
# ----------------------------------------------------
#  M      |    1ba    |        14059     |        1    |
# ----------------------------------------------------
#  S       |    2ba    |        14059     |        2    |
# ----------------------------------------------------
#  M      |    3ba    |        14059     |        3    |
# ----------------------------------------------------
#  S       |    4ba    |        14059     |        4    |
# ----------------------------------------------------
#  M      |    5ba    |        14059     |        5    |
# ----------------------------------------------------
#  S       |    6ba    |        14059     |        6    |
# ----------------------------------------------------
#  M      |    7ba    |        14059     |        7    |
# ----------------------------------------------------
```

```
# M     |   8ba   |       14059    |       8   |
# ---------------------------------------------------
# M     |   9ba   |       14059    |       9   |
# ---------------------------------------------------
# S     |   aba   |       14059    |       10  |
# ---------------------------------------------------
# M     |   bba   |       14059    |       11  |
# ---------------------------------------------------
# S     |   cba   |       14059    |       12  |
# ---------------------------------------------------
# M     |   dba   |       14059    |       13  |
# ---------------------------------------------------
# S     |   eba   |       14059    |       14  |
# ---------------------------------------------------
# M     |   fba   |       14059    |       15  |
# ********************************************************
#           PLRU of SET 14059 is 011011111010001
# ********************************************************
# CacheReads = 10
# CacheWrites = 10
# CacheHits=4
# CacheMisses=16
# Hit Ratio:0.20
```

PLRU

Update PLRU BITS

0 0BADBAD0

0 1BADBAD0

9

Output should be 000000010000000

RUNNING IN NORMAL MODE

Using specified file: plru.txt

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad0, Snoop Result: HIT

#

MESI State:S, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 1badbad0, Snoop Result: HIT

#

MESI State:S, TAG:1ba

PLRU = 000000010000000

Message to Higher Level Cache: SENDLINE

++

#

Valid Lines in LLC:

#

MESI | TAG | SET | WAY |

S | 0ba | 14059 | 0 |

S | 1ba | 14059 | 1 |

****

PLRU of SET 14059 is 000000010000000

****

CacheReads = 2

CacheWrites = 0

CacheHits=0

CacheMisses=2

Hit Ratio:0.00

EVICTION to 0th Way since it is LRU and check the PLRU bits

0 0BADBAD0

1 1BADBAD0

0 2BADBAD0

1 3BADBAD0

0 4BADBAD0

1 5BADBAD0

0 6BADBAD0

1 7BADBAD0

0 8BADBAD0

1 9BADBAD0

0 ABADBAD0

1 BBADBAD0

0 CBADBAD0

1 DBADBAD0

0 EBADBAD0

1 FBADBAD0

0 00ADBAD0

9

RUNNING IN NORMAL MODE

Using specified file: plru.txt

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad0, Snoop Result: HIT

MESI State:S, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 1badbad0, Snoop Result: HITM

#

MESI State:M, TAG:1ba

PLRU = 000000010000000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 2badbad0, Snoop Result: HITM

#

MESI State:S, TAG:2ba

PLRU = 000000010001000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 3badbad0, Snoop Result: HITM

#

MESI State:M, TAG:3ba

PLRU = 000000110001000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 4badbad0, Snoop Result: HITM

#

MESI State:S, TAG:4ba

PLRU = 000000110001010

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 5badbad0, Snoop Result: HITM

#

MESI State:M, TAG:5ba

PLRU = 000001110001010

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 6badbad0, Snoop Result: HITM

#

MESI State:S, TAG:6ba

PLRU = 000001110011010

Message to Higher Level Cache: SENDLINE

++

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 7badbad0, Snoop Result: HITM

#

MESI State:M, TAG:7ba

PLRU = 000011110011010

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 8badbad0, Snoop Result: HITM

#

MESI State:S, TAG:8ba

PLRU = 000011110011011

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 9badbad0, Snoop Result: HITM

#

MESI State:M, TAG:9ba

PLRU = 000111110011011

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: abadbad0, Snoop Result: HITM

#

MESI State:S, TAG:aba

PLRU = 000111110111011

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: bbadbad0, Snoop Result: HITM

#

MESI State:M, TAG:bba

PLRU = 001111110111011

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: cbadbad0, Snoop Result: HITM

#

MESI State:S, TAG:cba

PLRU = 001111110111111

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: dbadbad0, Snoop Result: HITM

#

MESI State:M, TAG:dba

PLRU = 011111110111111

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: ebadbad0, Snoop Result: HITM

#

MESI State:S, TAG:eba

PLRU = 011111111111111

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: fbadbad0, Snoop Result: HITM

#

MESI State:M, TAG:fba

PLRU = 111111111111111

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

Message to Higher Level Cache: EVICTLINE

BusOp: READ, Address: 00adbad0, Snoop Result: HITM

#

MESI State:S, TAG:00a

Message to Higher Level Cache: SENDLINE

++

#

Valid Lines in LLC:

#

MESI | TAG | SET | WAY |

S | 00a | 14059 | 0 |

M | 1ba | 14059 | 1 |

S | 2ba | 14059 | 2 |

M | 3ba | 14059 | 3 |

S | 4ba | 14059 | 4 |

M | 5ba | 14059 | 5 |

S | 6ba | 14059 | 6 |

M | 7ba | 14059 | 7 |

```
# S    |   8ba    |       14059    |       8   |
# ---------------------------------------------------
# M    |   9ba    |       14059    |       9   |
# ---------------------------------------------------
# S    |   aba    |       14059    |      10   |
# ---------------------------------------------------
# M    |   bba    |       14059    |      11   |
# ---------------------------------------------------
# S    |   cba    |       14059    |      12   |
# ---------------------------------------------------
# M    |   dba    |       14059    |      13   |
# ---------------------------------------------------
# S    |   eba    |       14059    |      14   |
# ---------------------------------------------------
# M    |   fba    |       14059    |      15   |
# ********************************************************
#           PLRU of SET 14059 is 111111101110100
# ********************************************************
# CacheReads = 9
# CacheWrites = 8
# CacheHits=0
# CacheMisses=17
# Hit Ratio:0.00
```

PROCESSOR OPERATIONS

INVALIDATE STATE

0 0BADBAD0

0 1BADBAD3

5 0BADBAD0

1 0BADBAD0

9

RUNNING IN NORMAL MODE

Using specified file: test.txt

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad0, Snoop Result: HIT

#

MESI State:S, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 1badbad3, Snoop Result: NOHIT

#

MESI State:E, TAG:1ba

PLRU = 000000010000000

Message to Higher Level Cache: SENDLINE

++

#

Operation: SNOOPED READ WITH INTENT TO MODIFY

SnoopResult: Address 0badbad0, SnoopResult: HITM

#

Message to Higher Level Cache: INVALIDATELINE

MESI:I

++

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 0badbad0, Snoop Result: NOHIT

#

MESI State:M, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

Valid Lines in LLC:

#

MESI | TAG | SET | WAY |

```
#  M     |    0ba    |         14059     |         0    |
# -------------------------------------------------------
#  E     |    1ba    |         14059     |         1    |
# ********************************************************
#             PLRU of SET 14059 is 000000000000000
# ********************************************************
# CacheReads = 2
# CacheWrites = 1
# CacheHits=0
# CacheMisses=3
# Hit Ratio:0.00
```

SHARED STATE

0 0BADBAD0

0 0BADBAD0

1 0BADBAD0

3 0BADBAD0

9

RUNNING IN NORMAL MODE

Using specified file: test.txt

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad0, Snoop Result: HIT

#

MESI State:S, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE HIT

MESI State:S, TAG:0ba

Message to Higher Level Cache: SENDLINE

PLRU = 000000000000000

```
# ++++++++++++++++++++++++++++++++++++++++++++++++++
#
# OPERATION: PROCESSOR WRITE
# HIT/MISS: CACHE HIT
# Message to Higher Level Cache: SENDLINE
# BusOp: INVALIDATE, Address: 0badbad0, Snoop Result: HIT
#
# MESI State:M, TAG:0ba
# PLRU = 000000000000000
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#
# Operation: SNOOPED READ
# SnoopResult: Address 0badbad0, SnoopResult: HITM
#
# MESI:S
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# Valid Lines in LLC:
#
# MESI   |    TAG    |          SET     |       WAY    |
# ---------------------------------------------------
#  S     |    0ba    |        14059     |        0     |
# **************************************************
#           PLRU of SET 14059 is 000000000000000
# **************************************************
```

CacheReads = 2

CacheWrites = 1

CacheHits=2

CacheMisses=1

Hit Ratio:0.67

MODIFIED STATE

1 0BADBAD0

0 0BADBAD0

1 0BADBAD0

9

RUNNING IN NORMAL MODE

Using specified file: test.txt

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 0badbad0, Snoop Result: HIT

#

MESI State:M, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE HIT

MESI State:M, TAG:0ba

Message to Higher Level Cache: SENDLINE

PLRU = 000000000000000

++

```
#
# OPERATION: PROCESSOR WRITE
# HIT/MISS: CACHE HIT
# Message to Higher Level Cache: SENDLINE
# MESI State:M, TAG:0ba
# PLRU = 000000000000000
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#
# Valid Lines in LLC:
#
# MESI   |    TAG    |          SET     |       WAY    |
# ------------------------------------------------------
#  M     |    0ba    |        14059     |        0     |
# ******************************************************
#           PLRU of SET 14059 is 000000000000000
# ******************************************************
# CacheReads = 1
# CacheWrites = 2
# CacheHits=2
# CacheMisses=1
# Hit Ratio:0.67
```

EXCLUSIVE STATE

0 0BADBAD3

0 0BADBAD3

1 0BADBAD3

9

RUNNING IN NORMAL MODE

Using specified file: test.txt

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad3, Snoop Result: NOHIT

#

MESI State:E, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

OPERATION: PROCESSOR READ

HIT/MISS: CACHE HIT

MESI State:E, TAG:0ba

Message to Higher Level Cache: SENDLINE

PLRU = 000000000000000

++

```
#
# OPERATION: PROCESSOR WRITE
# HIT/MISS: CACHE HIT
# Message to Higher Level Cache: SENDLINE
# MESI State:M, TAG:0ba
# PLRU = 000000000000000
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#
# Valid Lines in LLC:
#
# MESI   |    TAG    |          SET     |       WAY    |
# ------------------------------------------------------
#  M     |    0ba    |        14059     |        0     |
# ******************************************************
#           PLRU of SET 14059 is 000000000000000
# ******************************************************
# CacheReads = 2
# CacheWrites = 1
# CacheHits=2
# CacheMisses=1
# Hit Ratio:0.67
```

BUS OPERATIONS (SNOOPING)

INVALIDATE STATE

3 0BADBAD0

4 0BADBAD0

5 0BADBAD0

6 0BADBAD0

9

RUNNING IN NORMAL MODE

Using specified file: test.txt

Operation: SNOOPED READ

SnoopResult: Address 0badbad0, SnoopResult: NOHIT

#

++

Operation: SNOOPED READ WITH INTENT TO MODIFY

SnoopResult: Address 0badbad0, SnoopResult: NOHIT

#

++

Operation: SNOOPED INVALIDATE

SnoopResult: Address 0badbad0, SnoopResult: NOHIT

#

++

Valid Lines in LLC:

#

MESI | TAG | SET | WAY |

No Valid Lines in LLC

CacheReads = 0

CacheWrites = 0

CacheHits=0

CacheMisses=0

Hit Ratio:** Error (suppressible): (vsim-8604) cache_design.sv(156): NaN (not a number) resulted from a division operation.

-nan

SHARED STATE

0 0BADBAD0

3 0BADBAD0

4 0BADBAD0

5 0BADBAD0

0 0BADBAD0

6 0BADBAD0

0 0BADBAD0

3 1BADBAD0

4 1BADBAD0

5 1BADBAD0

6 1BADBAD0

9

Output

RUNNING IN NORMAL MODE

Using specified file: test.txt

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad0, Snoop Result: HIT

#

MESI State:S, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

```
# ++++++++++++++++++++++++++++++++++++++++++++++++++
#
# Operation: SNOOPED READ
# SnoopResult: Address 0badbad0, SnoopResult: HIT
#
# MESI:S
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# Operation: SNOOPED READ WITH INTENT TO MODIFY
# SnoopResult: Address 0badbad0, SnoopResult: HIT
#
# Message to Higher Level Cache: INVALIDATELINE
# MESI:I
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# OPERATION: PROCESSOR READ
# HIT/MISS: CACHE MISS
# BusOp: READ, Address: 0badbad0, Snoop Result: HIT
#
# MESI State:S, TAG:0ba
# PLRU = 000000000000000
# Message to Higher Level Cache: SENDLINE
# ++++++++++++++++++++++++++++++++++++++++++++++++++
#
# Operation: SNOOPED INVALIDATE
# SnoopResult: Address 0badbad0, SnoopResult: HIT
```

#

Message to Higher Level Cache: INVALIDATELINE

MESI:I

++

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad0, Snoop Result: HIT

#

MESI State:S, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

Operation: SNOOPED READ

SnoopResult: Address 1badbad0, SnoopResult: NOHIT

#

++

Operation: SNOOPED READ WITH INTENT TO MODIFY

SnoopResult: Address 1badbad0, SnoopResult: NOHIT

#

++

Operation: SNOOPED INVALIDATE

SnoopResult: Address 1badbad0, SnoopResult: NOHIT

#

```
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# Valid Lines in LLC:
#
# MESI   |    TAG    |          SET     |       WAY    |
# ----------------------------------------------------------
#  S     |    0ba    |        14059     |        0     |
# ----------------------------------------------------------
#        PLRU    |       000000000000000
# CacheReads = 3
# CacheWrites = 0
# CacheHits=0
# CacheMisses=3
# Hit Ratio:0.00
```

MODIFIED STATE

1 0BADBAD0

3 0BADBAD0

1 0BADBAD0

4 0BADBAD0

1 0BADBAD0

5 0BADBAD0

1 0BADBAD0

3 1BADBAD0

1 0BADBAD0

4 1BADBAD0

1 0BADBAD0

5 1BADBAD0

1 0BADBAD0

6 1BADBAD0

9

RUNNING IN NORMAL MODE

Using specified file: test.txt

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE MISS

BusOp: RWIM, Address: 0badbad0, Snoop Result: HIT

#

MESI State:M, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

Operation: SNOOPED READ

SnoopResult: Address 0badbad0, SnoopResult: HITM

#

MESI:S

++

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE HIT

Message to Higher Level Cache: SENDLINE

BusOp: INVALIDATE, Address: 0badbad0, Snoop Result: HIT

#

MESI State:M, TAG:0ba

PLRU = 000000000000000

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE HIT

Message to Higher Level Cache: SENDLINE

MESI State:M, TAG:0ba

PLRU = 000000000000000

```
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#
# Operation: SNOOPED READ WITH INTENT TO MODIFY
# SnoopResult: Address 0badbad0, SnoopResult: HITM
#
# Message to Higher Level Cache: GETLINE
# Message to Higher Level Cache: INVALIDATELINE
# MESI:I
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# OPERATION: PROCESSOR WRITE
# HIT/MISS: CACHE MISS
# BusOp: RWIM, Address: 0badbad0, Snoop Result: HIT
#
# MESI State:M, TAG:0ba
# PLRU = 000000000000000
# Message to Higher Level Cache: SENDLINE
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
#
# Operation: SNOOPED READ
# SnoopResult: Address 1badbad0, SnoopResult: NOHIT
#
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# OPERATION: PROCESSOR WRITE
# HIT/MISS: CACHE HIT
```

Message to Higher Level Cache: SENDLINE

MESI State:M, TAG:0ba

PLRU = 000000000000000

++

#

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE HIT

Message to Higher Level Cache: SENDLINE

MESI State:M, TAG:0ba

PLRU = 000000000000000

++

#

Operation: SNOOPED READ WITH INTENT TO MODIFY

SnoopResult: Address 1badbad0, SnoopResult: NOHIT

#

++

OPERATION: PROCESSOR WRITE

HIT/MISS: CACHE HIT

Message to Higher Level Cache: SENDLINE

MESI State:M, TAG:0ba

PLRU = 000000000000000

++

#

Operation: SNOOPED INVALIDATE

```
# SnoopResult: Address 1badbad0, SnoopResult: NOHIT
#
# ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
# Valid Lines in LLC:
#
# MESI   |    TAG    |          SET     |       WAY    |
# ------------------------------------------------------
#  M     |    0ba    |        14059     |        0     |


# ***********************PLRU***************************
#                                000000000000000
# CacheReads = 0
# CacheWrites = 7
# CacheHits=5
# CacheMisses=2
# Hit Ratio:0.71
```

EXCLUSIVE STATE

0 0BADBAD3

3 0BADBAD3

5 0BADBAD3

0 0BADBAD3

5 0BADBAD3

0 0BADBAD3

9

RUNNING IN NORMAL MODE

Using specified file: test.txt

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad3, Snoop Result: NOHIT

#

MESI State:E, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

Operation: SNOOPED READ

SnoopResult: Address 0badbad3, SnoopResult: HIT

#

MESI:S

++

Operation: SNOOPED READ WITH INTENT TO MODIFY

SnoopResult: Address 0badbad3, SnoopResult: HIT

#

Message to Higher Level Cache: INVALIDATELINE

MESI:I

++

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad3, Snoop Result: NOHIT

#

MESI State:E, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

Operation: SNOOPED READ WITH INTENT TO MODIFY

SnoopResult: Address 0badbad3, SnoopResult: HIT

#

Message to Higher Level Cache: INVALIDATELINE

MESI:I

++

OPERATION: PROCESSOR READ

HIT/MISS: CACHE MISS

BusOp: READ, Address: 0badbad3, Snoop Result: NOHIT

#

MESI State:E, TAG:0ba

PLRU = 000000000000000

Message to Higher Level Cache: SENDLINE

++

#

Valid Lines in LLC:

#

MESI | TAG | SET | WAY |

E | 0ba | 14059 | 0 |

****

PLRU of SET 14059 is 000000000000000

****

CacheReads = 3

CacheWrites = 0

CacheHits=0

CacheMisses=3

Hit Ratio:0.00