

RESIDUE CACHE IMPLEMENTATION

Design: -

- Address - 32 bits (stored in 8-bit hexadecimal format).
- Data - 32 bytes (stored in 64-bit hexadecimal format).
- L1 cache- Direct Mapped cache with 64 sets and 32-byte data size.
- L2 cache- Direct Mapped cache with 512 sets and 16-byte lines.
- Cache policy - Inclusive.
- Residue cache - Direct mapped cache with 128 sets and 16-byte lines.
- Encoding cache - Direct mapped cache (without tag field) with 512 sets, 33-bit lines which stores compression information and uncompressed size information.

Data Storage: -

- L2 cache stores data in compressed form generated using a compression algorithm.
- Often compressed data generated using the compression algorithm will exceed 16 bytes. But, since L2 cache can store up to 16 bytes of compressed data in a line, excess data needs to be stored in residue cache.
- Since residue cache can store up to 16 bytes on excess data in a line, there is no benefit of compressing the excess data before storing it in residue cache.

NOTE: -Data is compressed (starting from MSB) until we get 32 bytes of compressed data. The leftover/excess data which are not compressed are stored in residue cache in uncompressed form.

Compression Scheme: -

- Each line in trace file has 32-byte data (stored in 64 bits hexadecimal format).
- The algorithm checks if consecutive hexadecimal bits of are same or not. If they are same($\text{data}[i] = \text{data}[i+1]$) it is compress into one single bit (i.e., $\text{data}[i]$) and corresponding encoding bit in encoding cache is set to 1.
- Example -
 - 1) 0xff00011acbbd will be compressed to 0xf001acbd
 - 2) 0x0000000000 will be compressed to 0x000000

Encoding cache: -

- Each line of encoding cache is associated with a particular I2 cache line.
- It stores the compression information in the first 32 bits and uncompressed size information in the remaining 1 bit.
- This information is used at the time of decompression.

Compression Information: -

- On compression of data at index i and $i+1$ the corresponding encoding bit is set to 1 else it is set to 0.
- Example: -
 - 1) 0x00000ffffff9c5 will be compressed to 0x000ffff9(32 bits) and c5 the leftover residue bits.
Encoding cache = 11011110(initial 8 bits only)

Uncompressed size information: -

1-> Completely compressible in L2 /no excess data.

0-> otherwise (excess data generated).

Example: -

Address: - 0x1ffff50

Data:-

0xdd4c4cccccccd4dccccd4ccd4c4b99c8474648c5c6c6c5c7c4c8c888c8c6c99

L1_index = 58 and L1_tag = 00011111111111111111

1. L1 hit/miss is checked. If it is hit then l1_hit is incremented.
Else l1_miss is increased and we move on to step 2.

Res_index = 117 and Res_tag = 00011111111111111111

2. Residue cache hit/miss is checked. If it is hit then l2_hit is incremented. Else we move on to step 3.

L2_index = 501 and L2_tag = 00011111111111111111

3. L2 hit/miss is checked. If it is miss then we increment l2_miss, add data in L1 cache(uncompressed), add data in L2 cache*(compressed) and residue (Excess).
Else we move on to step 4.

*During add in L2, if it causes eviction in L2, it is also evicted from L1 as it is Inclusive cache policy.

Compressed data: - dd4c4cccd4dcd4cd4c4b9c8474648c

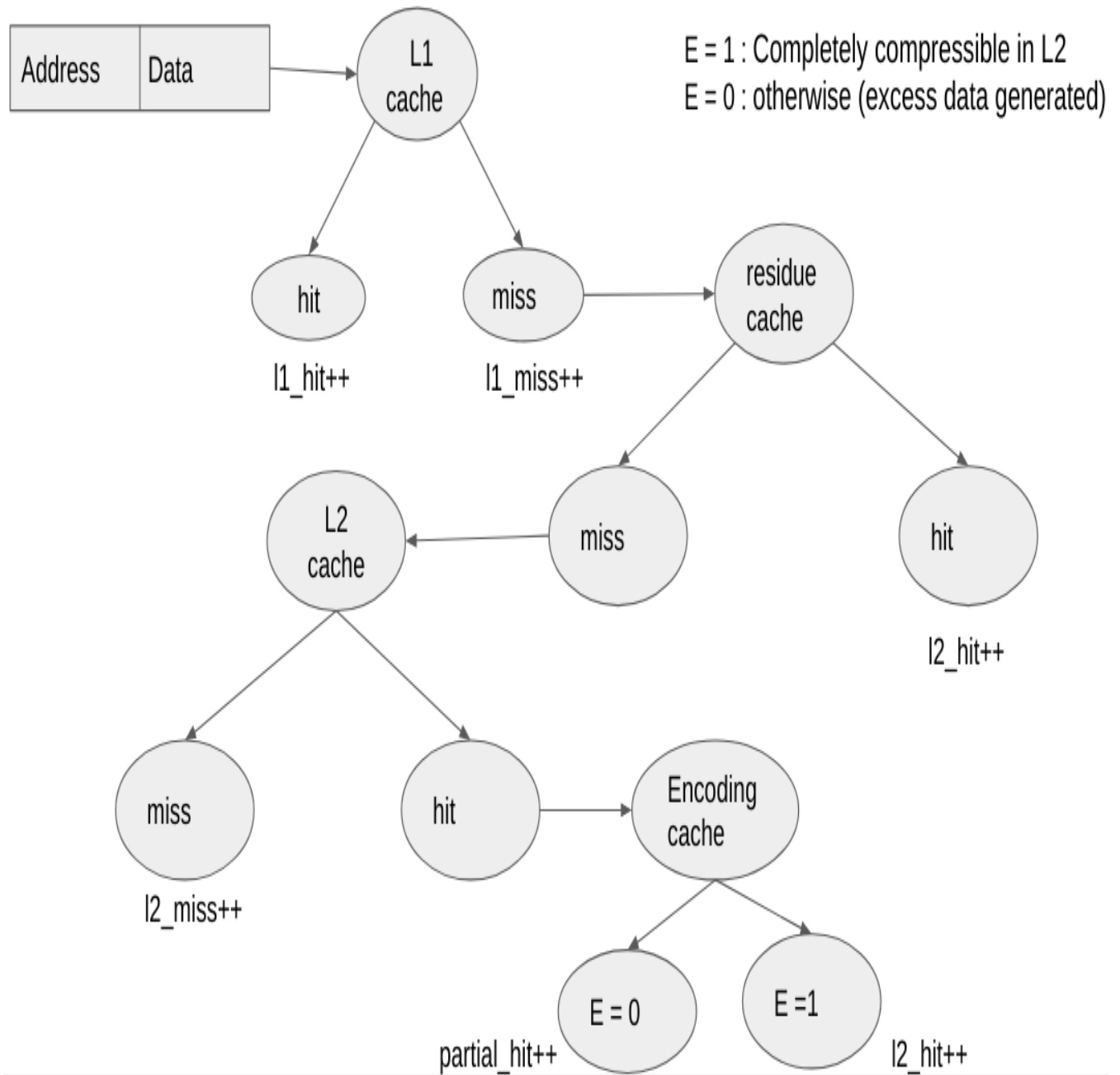
Residue/Excess data: - 5c6c6c5c7c4c8c888c8c6c99

The compressed data will be added to the l2_cache and the remaining will go to the residue cache.

Encoding_Index = L2_index = 501

4. Uncompressed size bit of the encoding cache corresponding to that address is checked. If it is 1(it is completely in L2), it is an l2-hit and l2_hit is incremented. Else it is a partial hit and partial_hit is incremented.

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Results: -

The results were obtained using mi benchmark.

1)

File Name: - CRC32

Cache	Hits	Misses	%Hits
L1	853906	146094	85.39
L2_partial	143490	-	-
L2	1575	1029	60.60

2)

File Name: - BasicMath

Cache	Hits	Misses	%Hits
L1	567830	268449	67.8
L2_partial	199075	-	-
L2	57808	11566	83.32

3)

File Name: -Patricia

Cache	Hits	Misses	%Hits
L1	686080	313919	68.6
L2_partial	172918	-	-
L2	42403	98598	30.07

4)

File Name: - sha

Cache	Hits	Misses	%Hits
L1	979734	20266	97.97
L2_partial	15168	-	-
L2	2865	2233	56.19

5)

File Name:-string_search

Cache	Hits	Misses	%Hits
L1	474072	525928	47.4
L2_partial	254962	-	
L2	254362	16604	93.87