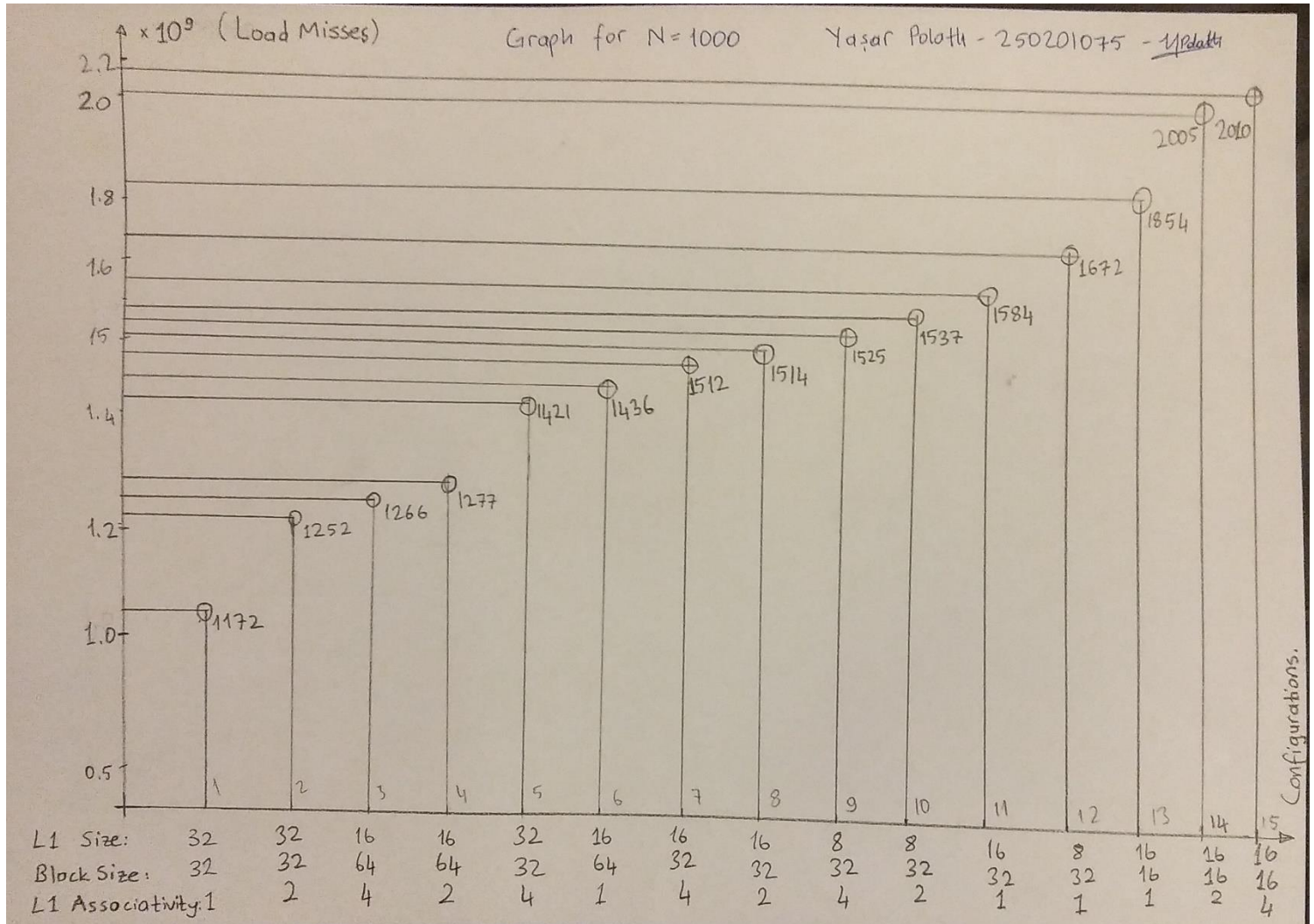


# CENG311 Fall 2020

## REPORT FOR PROGRAMMING ASSIGNMENT 4

Firstly, let us start the report with default matrix size (N=1000). Here is the graph that shows number of load-misses for L1 data cache:



In order to comment the cache parameters differently let's look at this image:

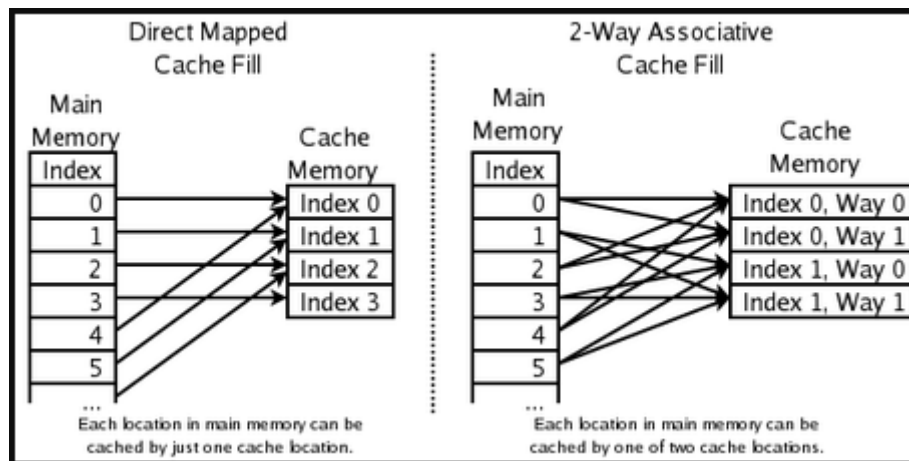
**Associativity Increases**

Configuration	# Load-Hits	# Load-Misses	# Load-Accesses	# Store-Hits	# Store-Misses	# Store-Accesses	# Total-Hits	# Total-Misses	# Total-Accesses
dcache_1000_16_16_1.out	20260512779	1854295088	22114807867	2664753998	17038872	2681792870	22925266777	1871333960	24796600737
dcache_1000_16_16_2.out	20108969991	2005837876	22114807867	2678144585	3648285	2681792870	22787114576	2009486161	24796600737
dcache_1000_16_16_4.out	20104397851	2010410016	22114807867	2678273215	3519655	2681792870	22782671066	2013929671	24796600737
dcache_1000_16_32_1.out	20530755573	1584052294	22114807867	2662197517	19595353	2681792870	20600050166	1514757701	22114807867
dcache_1000_16_32_2.out	20600050166	1514757701	22114807867	2677750064	4042806	2681792870	20600050166	1514757701	22114807867
dcache_1000_16_32_4.out	20602167432	1512640433	22114807865	2678052278	3740592	2681792870	20602167432	1512640433	22114807865
dcache_1000_16_64_1.out	20678051795	1436756072	22114807867	2645190008	36602862	2681792870	20836900858	1277907009	22114807867
dcache_1000_16_64_2.out	20836900858	1277907009	22114807867	2675606197	6186673	2681792870	20836900858	1277907009	22114807867
dcache_1000_16_64_4.out	20848041049	1266766818	22114807867	2676444285	5348585	2681792870	20848041049	1266766818	22114807867

**Block size increases**

As you can see when the associativity becomes larger (red line), miss rate getting smaller. Because the associativity means more room for data (2 associativity means, 2 blocks for 1 data) to be placed. And it increases the hit rate, decreases the misses naturally.

Some pictures from lecturer materials that show what I try to explain:



**Associativity** allows a set of blocks to go in cache entries. When the one of block is full, data can be located another block which is element of the same set.

There is a coincidence to must indicate is that when the cache size and block size is equal (when they both are 16 or 32), miss rate is getting bigger with associativity. I am not sure, but this might happen because block size becomes a significant portion of the cache size (actually their size is equal) and we cached lots of values ( $N=1000$ ) that we use just once.

When the cache size and block size are both small there is high miss rate is inevitable. To lower these misses associativity can be increased.

Second part of my commenting, I will explain **block size** differences.

When the block size is small, we cannot use spatial locality. This situation occurs more misses.

As you can see (blue line) when the block size increases, misses getting smaller.

And moreover, the block size matters a lot because the row-majority of matrix implementation. We can access continuous elements of matrix easily when the block size is bigger, due to spatial locality.

---

When we consider the **different cache sizes** about load misses let us look at this image:

The image shows six Notepad++ windows displaying cache statistics for different cache sizes. A green arrow points to the 'L1 Cache Size Increases' window, highlighting the decrease in load misses as cache size increases.

Cache Size	Load-Hits	Load-Misses	Load-Misses %
dcache_1000_8_32_1.out	20442229650	1672578217	7.56%
dcache_1000_8_32_2.out	20577367149	1537440718	6.95%
dcache_1000_8_32_4.out	20589604408	1525203459	6.90%
dcache_1000_32_32_1.out	20942407405	1172400462	5.30%
dcache_1000_32_32_2.out	20862393476	1252414391	5.66%
dcache_1000_32_32_4.out	20693760952	1421046913	6.43%

As you can see when the cache size increases (green line), number of load-misses getting decrease. Because bigger cache size can exploit temporal locality better. There is a pros about miss rates, cons about latency for larger cache size but we are just focusing number of load-misses.

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Secondly, let us check the results for another matrix size (N=10).

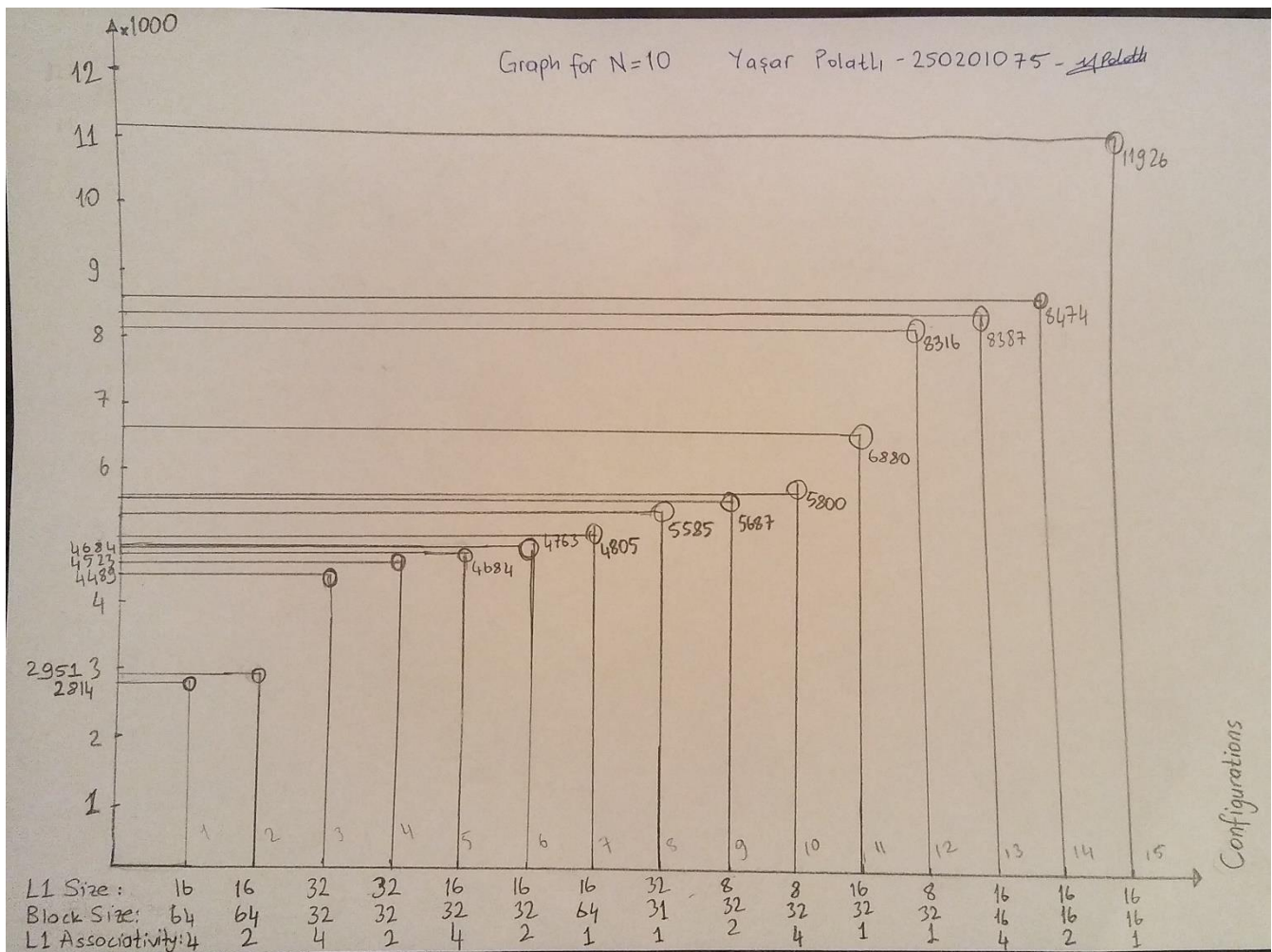
In this scenario there is not much difference that should be indicated.

But some observations about like this:

- Since number of operations decreases miss rate is smaller than 1000. When the operation is data intensive (N=1000) there is lots of deletion operation occurs and this affects overall rate. But when the N=10 there is not much deletion needed so miss-rate (%) is smaller than before.
- There is no coincidence happening here since data intense is small.

Other than these, observations and comment would be the same with as N=1000.

Here is the values and the graph for N=10:



<div> <div>C:\Users\myasa\Desktop\outs\outs\dcache_10_8_32_1.out</div> <div>File Edit Selection Find View Goto Tools Project Preferences Help</div> <div> <div>dcache_10_8_32_1.out</div> <div> <div>1</div> <div>PIN:MEMLATENCIES 1.0. 0x0</div> <div>2</div> <div>#</div> <div>3</div> <div># DCACHE stats</div> <div>4</div> <div>#</div> <div>5</div> <div># L1 Data Cache:</div> <div>6</div> <div># Load-Hits: 136145 94.24%</div> <div>7</div> <div># Load-Misses: 8316 5.76%</div> <div>8</div> <div># Load-Accesses: 144461 100.00%</div> <div>9</div> <div>#</div> <div>10</div> <div># Store-Hits: 60257 96.33%</div> <div>11</div> <div># Store-Misses: 2296 3.67%</div> <div>12</div> <div># Store-Accesses: 62553 100.00%</div> <div>13</div> <div>#</div> <div>14</div> <div># Total-Hits: 196402 94.87%</div> <div>15</div> <div># Total-Misses: 10612 5.13%</div> <div>16</div> <div># Total-Accesses: 207014 100.00%</div> <div>17</div> <div>#</div> </div> <div>Line 1, Column 1 Tab Size: 4 Plain</div> </div> </div>	<div> <div>C:\Users\myasa\Desktop\outs\outs\dcache_10_8_32_2.out</div> <div>File Edit Selection Find View Goto Tools Project Preferences Help</div> <div> <div>dcache_10_8_32_2.out</div> <div> <div>1</div> <div>PIN:MEMLATENCIES 1.0. 0x0</div> <div>2</div> <div>#</div> <div>3</div> <div># DCACHE stats</div> <div>4</div> <div>#</div> <div>5</div> <div># L1 Data Cache:</div> <div>6</div> <div># Load-Hits: 138774 96.06%</div> <div>7</div> <div># Load-Misses: 5687 3.94%</div> <div>8</div> <div># Load-Accesses: 144461 100.00%</div> <div>9</div> <div>#</div> <div>10</div> <div># Store-Hits: 61183 97.81%</div> <div>11</div> <div># Store-Misses: 1370 2.19%</div> <div>12</div> <div># Store-Accesses: 62553 100.00%</div> <div>13</div> <div>#</div> <div>14</div> <div># Total-Hits: 199957 96.59%</div> <div>15</div> <div># Total-Misses: 7057 3.41%</div> <div>16</div> <div># Total-Accesses: 207014 100.00%</div> <div>17</div> <div>#</div> </div> <div>Line 1, Column 1 Tab Size: 4 Plain</div> </div> </div>	<div> <div>C:\Users\myasa\Desktop\outs\outs\dcache_10_8_32_4.out</div> <div>File Edit Selection Find View Goto Tools Project Preferences Help</div> <div> <div>dcache_10_8_32_4.out</div> <div> <div>1</div> <div>PIN:MEMLATENCIES 1.0. 0x0</div> <div>2</div> <div>#</div> <div>3</div> <div># DCACHE stats</div> <div>4</div> <div>#</div> <div>5</div> <div># L1 Data Cache:</div> <div>6</div> <div># Load-Hits: 138661 95.99%</div> <div>7</div> <div># Load-Misses: 5800 4.01%</div> <div>8</div> <div># Load-Accesses: 144461 100.00%</div> <div>9</div> <div>#</div> <div>10</div> <div># Store-Hits: 61112 97.70%</div> <div>11</div> <div># Store-Misses: 1441 2.30%</div> <div>12</div> <div># Store-Accesses: 62553 100.00%</div> <div>13</div> <div>#</div> <div>14</div> <div># Total-Hits: 199773 96.50%</div> <div>15</div> <div># Total-Misses: 7241 3.50%</div> <div>16</div> <div># Total-Accesses: 207014 100.00%</div> <div>17</div> <div>#</div> </div> <div>Line 1, Column 1 Tab Size: 4 Plain</div> </div> </div>
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<div> <div>dcache_10_16_16_1.out</div> <div>File Edit Selection Find View Goto Tools Project Preferences Help</div> <div> <div>dcache_10_16_16_1.out</div> <div> <div>1</div> <div>PIN:MEMLATENCIES 1.0. 0x0</div> <div>2</div> <div>#</div> <div>3</div> <div># DCACHE stats</div> <div>4</div> <div>#</div> <div>5</div> <div># L1 Data Cache:</div> <div>6</div> <div># Load-Hits: 132535 91.74%</div> <div>7</div> <div># Load-Misses: 11926 8.26%</div> <div>8</div> <div># Load-Accesses: 144461 100.00%</div> <div>9</div> <div>#</div> <div>10</div> <div># Store-Hits: 58940 94.22%</div> <div>11</div> <div># Store-Misses: 3613 5.78%</div> <div>12</div> <div># Store-Accesses: 62553 100.00%</div> <div>13</div> <div>#</div> <div>14</div> <div># Total-Hits: 191475 92.49%</div> <div>15</div> <div># Total-Misses: 15539 7.51%</div> <div>16</div> <div># Total-Accesses: 207014 100.00%</div> <div>17</div> <div>#</div> </div> <div>Line 1, Column 1 Tab Size: 4 Plain</div> </div> </div>	<div> <div>dcache_10_16_16_2.out</div> <div>File Edit Selection Find View Goto Tools Project Preferences Help</div> <div> <div>dcache_10_16_16_2.out</div> <div> <div>1</div> <div>PIN:MEMLATENCIES 1.0. 0x0</div> <div>2</div> <div>#</div> <div>3</div> <div># DCACHE stats</div> <div>4</div> <div>#</div> <div>5</div> <div># L1 Data Cache:</div> <div>6</div> <div># Load-Hits: 135985 94.13%</div> <div>7</div> <div># Load-Misses: 8474 5.87%</div> <div>8</div> <div># Load-Accesses: 144459 100.00%</div> <div>9</div> <div>#</div> <div>10</div> <div># Store-Hits: 60260 96.33%</div> <div>11</div> <div># Store-Misses: 2293 3.67%</div> <div>12</div> <div># Store-Accesses: 62553 100.00%</div> <div>13</div> <div>#</div> <div>14</div> <div># Total-Hits: 196245 94.80%</div> <div>15</div> <div># Total-Misses: 10767 5.20%</div> <div>16</div> <div># Total-Accesses: 207012 100.00%</div> <div>17</div> <div>#</div> </div> <div>Line 1, Column 1 Tab Size: 4 Plain</div> </div> </div>	<div> <div>dcache_10_16_16_4.out</div> <div>File Edit Selection Find View Goto Tools Project Preferences Help</div> <div> <div>dcache_10_16_16_4.out</div> <div> <div>1</div> <div>PIN:MEMLATENCIES 1.0. 0x0</div> <div>2</div> <div>#</div> <div>3</div> <div># DCACHE stats</div> <div>4</div> <div>#</div> <div>5</div> <div># L1 Data Cache:</div> <div>6</div> <div># Load-Hits: 136072 94.19%</div> <div>7</div> <div># Load-Misses: 8387 5.81%</div> <div>8</div> <div># Load-Accesses: 144459 100.00%</div> <div>9</div> <div>#</div> <div>10</div> <div># Store-Hits: 60320 96.43%</div> <div>11</div> <div># Store-Misses: 2233 3.57%</div> <div>12</div> <div># Store-Accesses: 62553 100.00%</div> <div>13</div> <div>#</div> <div>14</div> <div># Total-Hits: 196392 94.87%</div> <div>15</div> <div># Total-Misses: 10620 5.13%</div> <div>16</div> <div># Total-Accesses: 207012 100.00%</div> <div>17</div> <div>#</div> </div> <div>Line 1, Column 1 Tab Size: 4 Plain</div> </div> </div>
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