Computer Organization

Cache Simulation

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ECEN 4593

Introduction

The goal of the project was to simulate a memory system that implements a two level cache structure composed of L1 instruction, L1 data, and a unified L2 cache. In this system, misses in L1 are handled by L2, and misses in L2 are handled by main memory. The simulation is designed to evaluate the performance and cost of specific hardware configurations given real world traces.

Results

An initial way to view the performance of the traces with specific configurations is to look at the execution times for those configurations. Fig. 1 shows each trace and its execution time for each configuration in relation to all the other traces.

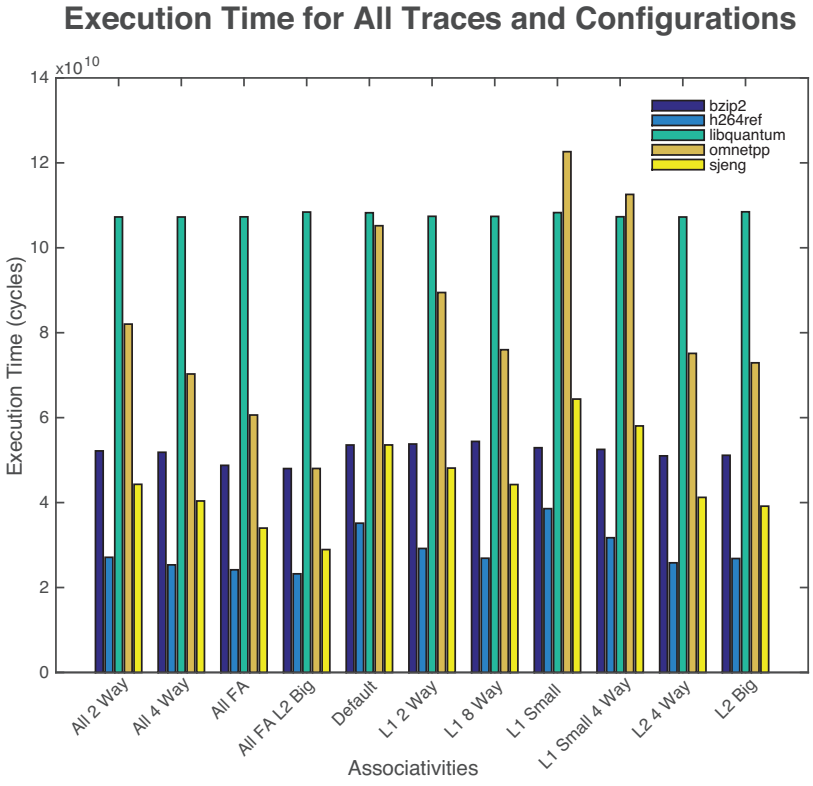


Figure 1: Execution times of all traces with correspondence to all configurations

The execution time for some traces vary very little with changes in cache configuration while other traces are largely effected by the cache configuration. As seen in Fig. 1, libquantum has a very steady execution time which does not seem to depend on cache configuration. A trace like omnetpp however, is very dependent on the cache configuration. The execution times range from 40 billion cycles to 120 billion cycles.

Another way to compare the performance of each trace is to look at the Cycles per Instruction (CPI). This is plotted in Fig. 2.

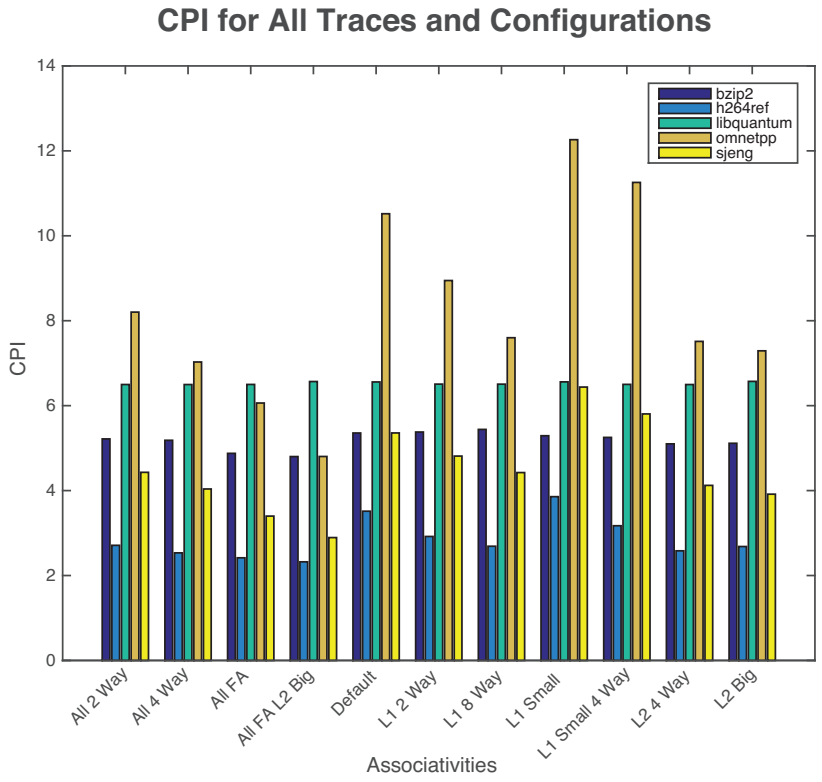


Figure 2: CPI of all traces with correspondence to all configurations

Similar to the execution times in Fig. 1, Fig. 2 shows that the configuration of the cache can dramatically effect the CPI.

Figures. 1 & 2 show that Fully Associative configurations give the fastest results, but at a cost.

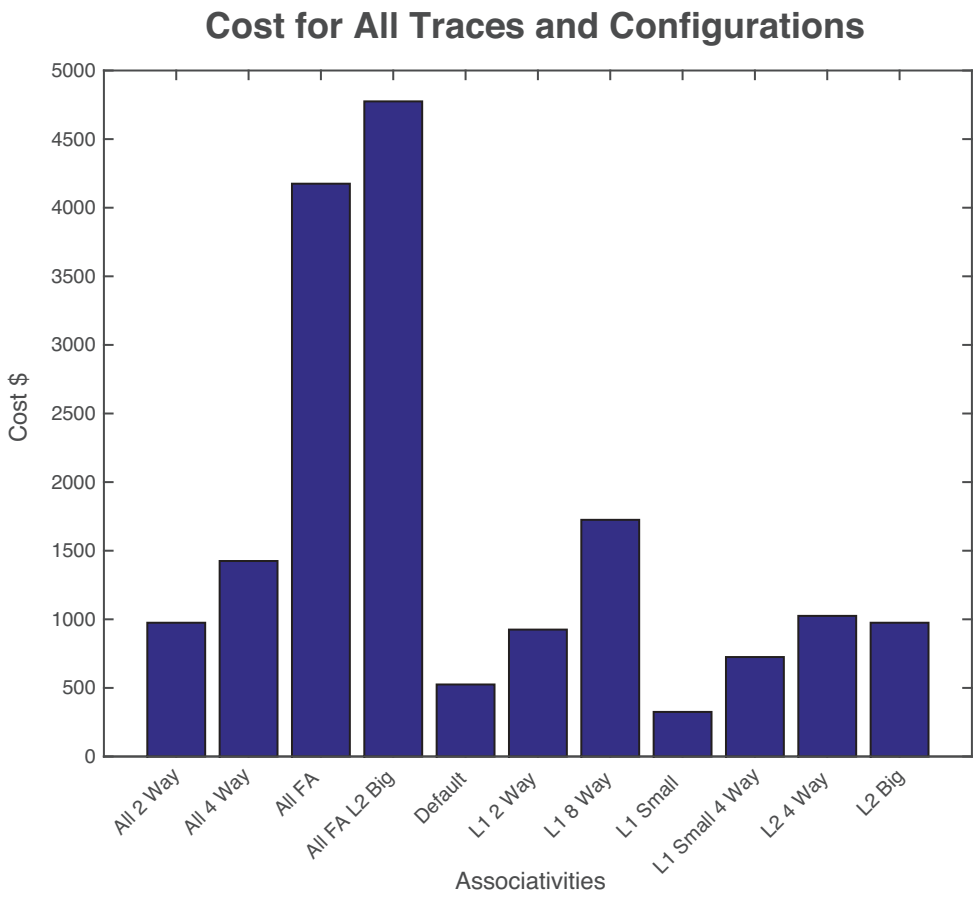


Figure 3: Cost of all the different configurations

Fig. 3 shows the total cost of having each configuration. The fully associative configurations are much more expensive than the other configurations. Viewing both Fig. 2 & 3 show that cost transfers quite proportionally to performance.

Discussion

Examining the execution times of each configuration for the separate traces is not a useful way to measure configuration performance. The execution time is dependent on the number of instructions in each trace file, and so varies both by configuration and trace size. To eliminate this variable, we divided the execution time or cycles by the number of references

in each trace to find the CPI. This can seen in Fig. 2.

The most noteworthy feature of Fig. 2 is the variable dependence of trace files on configuration. Both traces libquantum and bzip demonstrate extremely low variance across configurations, while traces such as onmetpp and sjeng demonstrate high variance. This variance is due to function and structure of the code written for these trace files. For example, it is likely that libquantum and bzip frequently reference spatially dissimilar locations in memory, making the spatial locality benefit of caching obsolete. Additionally, if libquantum and bzip were written sequentially and do not frequently loop, the benefit of temporal locality in caching is lost. Traces onmetpp and sjeng however are examples of code that frequently references spatially and temporally similar locations of memory. Frequent looping and indexing of large, static data arrays are good examples of this.

When considering the best performing configuration, it is useful to consider the average instructions per cycle versus configuration. Fig. 4 demonstrates this relationship. An optimally designed multi-purpose architecture should maximize the IPC for all traces. The fully associative cases exhibit the highest instructions per cycle for all traces. This is because a fully associative cache utilizes a least recently used (LRU) buffer for a single set. In direct mapped and non-fully associative configurations multiple locations in memory or lower tier caches can reference the same index and cause the cache to miss. In the fully associative case, the LRU determines what block is overwritten based on temporal locality.

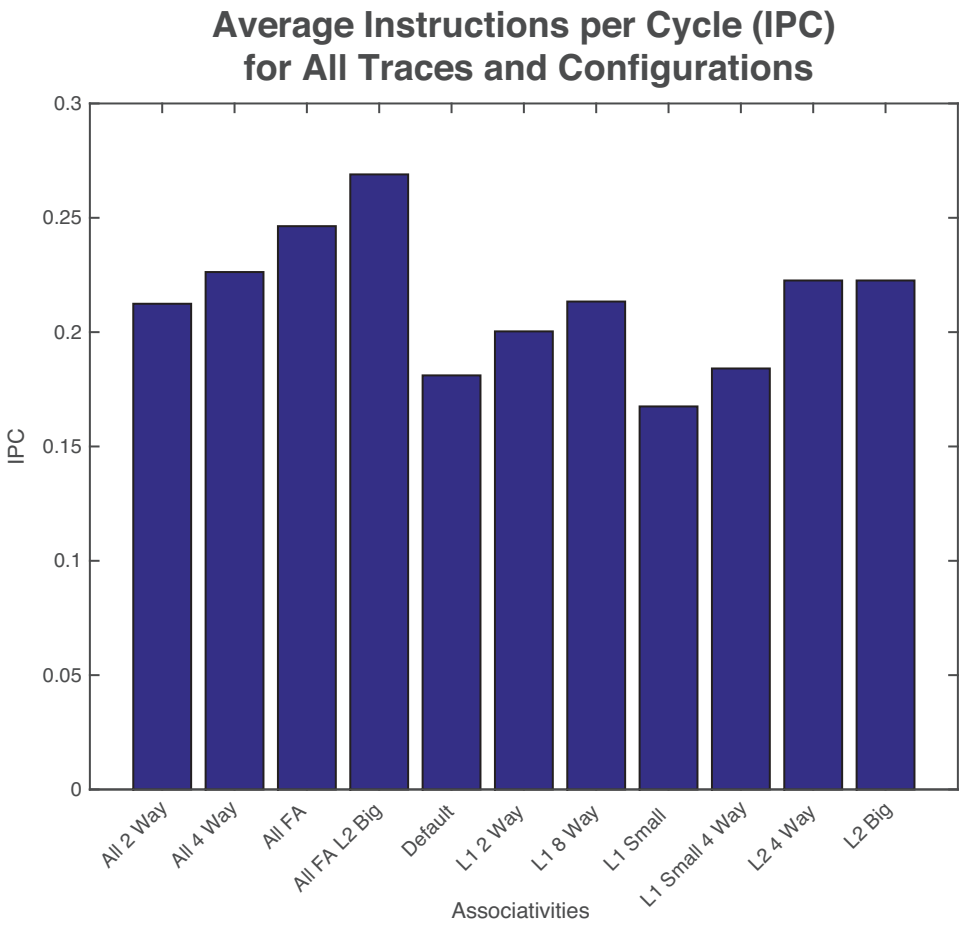


Figure 4: Average IPC for each configuration

Pure instructions per cycle performance however is not the only consideration to make when choosing the best machine. Cost is an important factor. While the FA configurations are the fastest on average, they are also the most expensive. FA caches are extremely expensive, and in the simulation according to specifications cost in the thousands of dollars. When considering what system to buy, it is therefore useful to look at IPC per dollar, as seen in Fig. 5.

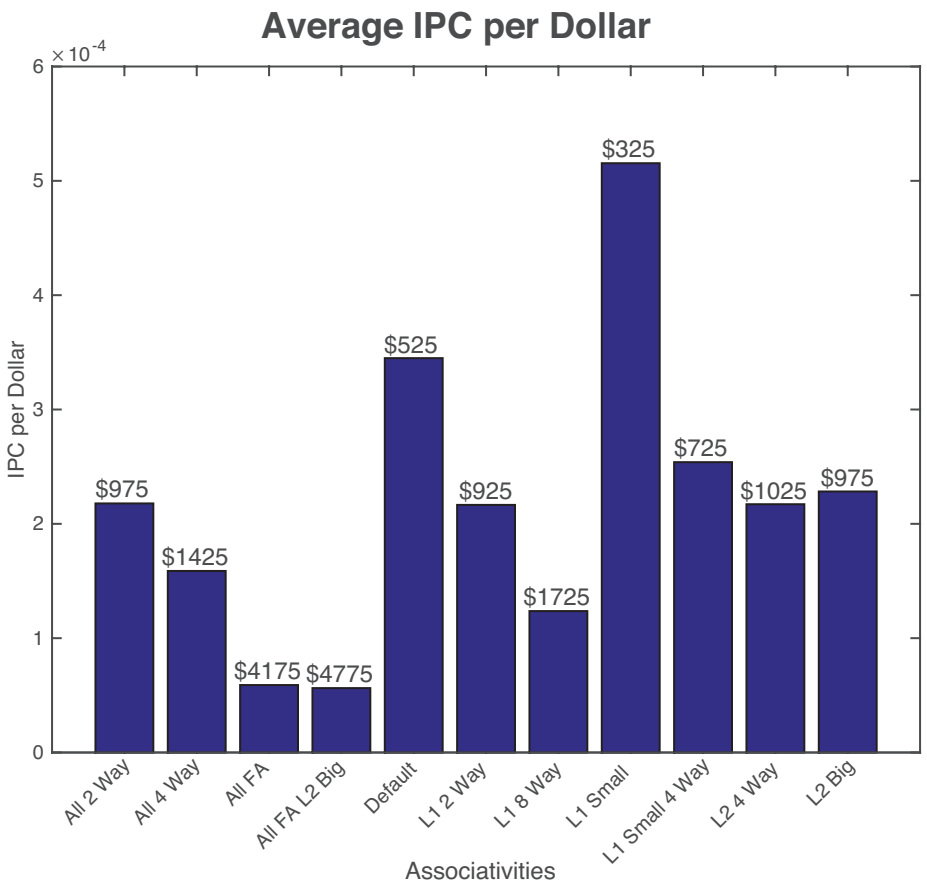


Figure 5: Average IPC per Dollar for each configuration

When choosing a system, Fig. 5 displays each configuration's performance weighted by its price. It is however also useful to identify what configuration gives the maximum increase in performance from the cheapest configuration per dollar. Fig. 6 exhibits these results. L1 small is the cheapest configuration, and from the figure it is apparent that L2 big gives the maximum performance increase per dollar. Interestingly, the FA cases yield the smallest performance increase per dollar due to their high cost.

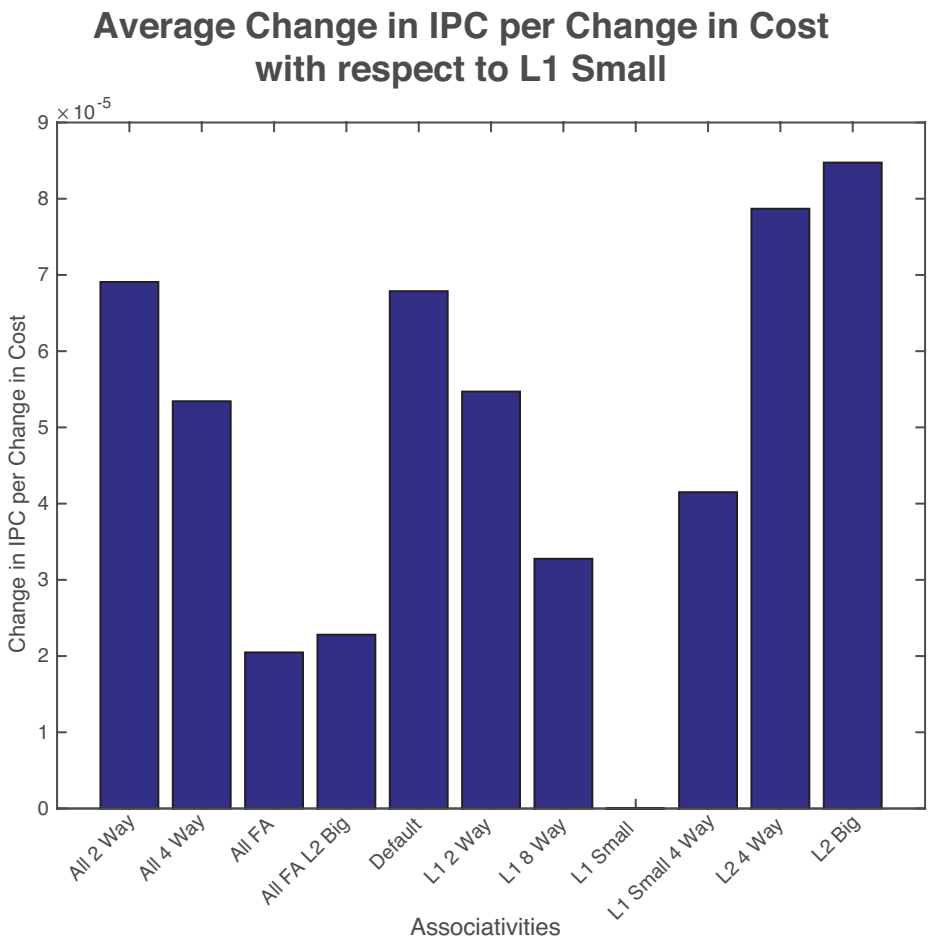
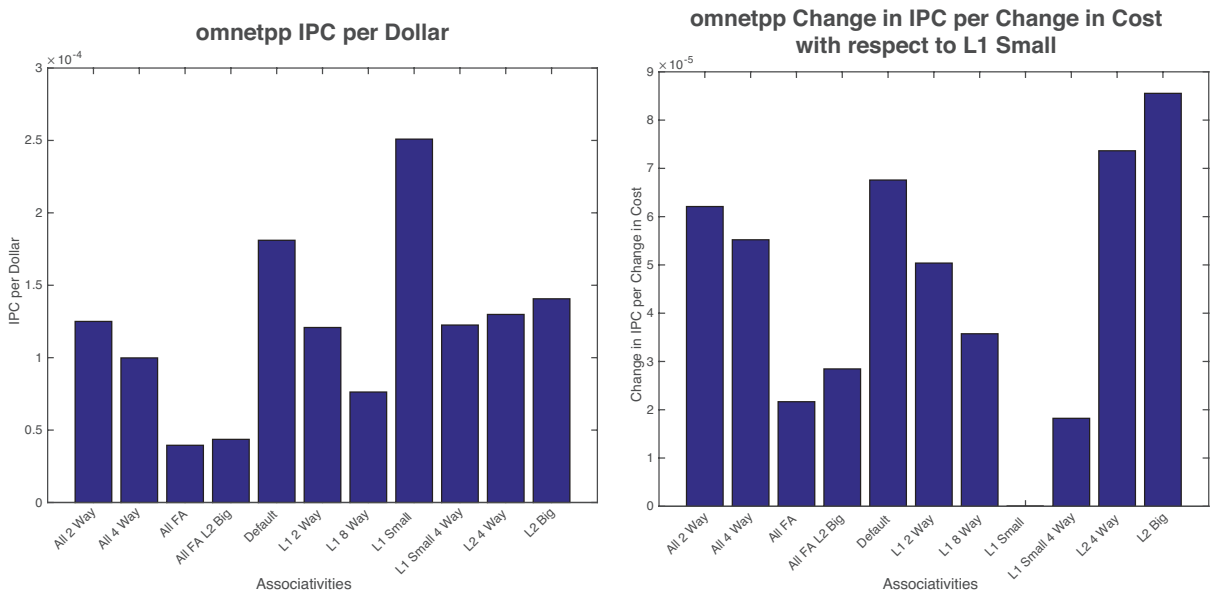


Figure 6: Change in average IPC per change in cost for each configuration

These results are useful only to selecting a general purpose system. Clearly, configurations such as libquantum and onmetpp vary considerably in their utilization of the cache structure. Due to the fact that libquantum does not vary in performance over configuration, it is unnecessary to purchase any cache configuration other than the cheapest case, L1 small to optimally execute this trace file. The trace onmetpp has a high variance, and its respective IPC per dollar as well as change in IPC per dollar should be considered for each configuration. The resulting figures can be seen below in Fig. 7a and Fig. 7b.



(a) IPC per Dollar

(b) Change in IPC per change in cost

Figure 7: omnetpp IPC

From the figures above, it is evident that onmetpp follows a similar trend as the averaged case. This is because the program omnetpp exhibited spatial and temporal locality and therefore benefitted from the cache structure.

The chunksize of main memory is an important consideration when evaluating what configuration has the best performance given its cost. The chunksize is the width of the bus interface to memory. Access time to main memory is extremely slow, and so it is beneficial to performance to read as many bytes as possible when memory is accessed. The trade-off is cost, and so it is useful to observe the performance increase versus cost of various configurations of memory chunksize. The default cache configuration for chucksizes of 8, 16, 32, and 64 bytes are compared to their respective costs in Fig. 8 below.

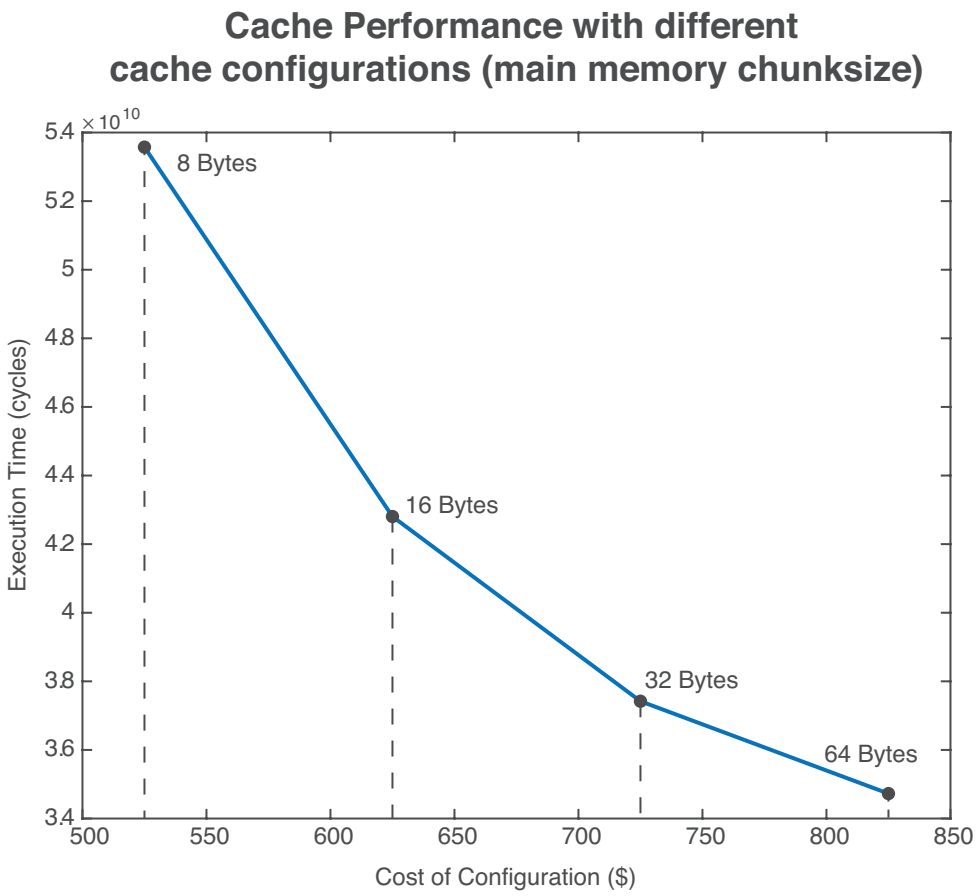


Figure 8

The largest performance increase occurs between 8 and 16 bytes. As chunksize is further increased, the change in performance begins to decrease. Extrapolating from the graph, it is unlikely that a chunksize greater than 64 bytes would yield a significantly greater performance increase. The performance increase from 8 to 16 bytes is approximately double that of the performance increase from 16 to 32 bytes for the same change in cost.

Conclusion

The simulation successfully evaluated input traces for various hardware configurations. Certain traces demonstrated more variance than others, depending on the structure and functionality of the code used to generate them. Traces that exhibited low variance and relatively high cycles per instruction were likely written sequentially, did not utilize large arrays, and had few loops.

The cost of the hardware is an important consideration when evaluating real world performance increases. While the FA configurations yielded the highest instructions per cycle, they were also the most expensive and therefore not the best performance increase per dollar. Additionally, some traces such as libquantum that had very low variance across configurations do not require more advanced hardware than the low cost configuration of L1-small. Traces such as onmetpp however have very high variance and benefit greatly from more expensive cache structures. When considering the larges performance increase per dollar from the lowest cost configuration, doubling the L2 cache size and changing cache associativity to 2-way (L2-Big) was the best option.

Finally, memory chunksize is an important variable in performance and cost. As chunksize increases, the relative gains in performance are diminished. After a chunksize of 64, performance change is negligible compared the increase in price. Initially doubling the chunksize from 8 to 16 however yielded significant performance gains.

Given more time, we would run more simulations to confirm and identify trends in our results. Many of the configurations tested changed more than one cache attribute such as size and associativity, making the results difficult to evaluate. Simulating all cache configurations would give greater insight into what configuration changes yield the largest performance increases per cost.

MAIN.C

```
/*
    Cache Simulation Project -- ECEN 4593
    Authors:
        Andrew Kee
        Ryan Montoya
*/

#include <stdio.h>
#include <stdlib.h>
#include "cache.h"

int main(int argc, char *argv[]){
    cache* l1_data  = malloc( sizeof(cache));
    cache* l1_inst  = malloc( sizeof(cache));
    cache* l2       = malloc( sizeof(cache));
    cache* main_mem = malloc( sizeof(cache));

    results* cache_results = malloc( sizeof(results));
    cache_results->num_inst = 0;
    cache_results->num_reads = 0;
    cache_results->num_writes = 0;
    cache_results->flush_time = 0;
    cache_results->read_time = 0;
    cache_results->inst_time = 0;
    cache_results->flush_cnt = 0;
    cache_results->num_invalid = 0;

    char * x;
    if (argv[1])
        x = argv[1];
    else
        x = "Config/defaults.dat";

    char * outputFile;
    if (argv[2])
        outputFile = argv[2];
    else
        outputFile = "results.dat";

    // printf("%s\n", x);
    parse_config(x, l1_data, l1_inst, l2, main_mem);
    allocate_blocks(l1_data, l1_inst, l2);
    init_cache(l1_data);
    init_cache(l1_inst);
    init_cache(l2);
    read_trace(l1_data, l1_inst, l2, cache_results);
    report(l1_data, l1_inst, l2, main_mem, cache_results, outputFile);

    cache_dealloc(l1_inst);
    cache_dealloc(l1_data);
    cache_dealloc(l2);
    free(cache_results);


    return 0;
}
```

CACHE.H

```
#ifndef CACHE_H
#define CACHE_H

#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#include <string.h>
#include <math.h>
#include <time.h>


typedef unsigned int uint;
typedef unsigned long ul;
typedef unsigned long long ull;
typedef unsigned long long int ulli;

typedef struct results
{
    ulli num_inst;
    ulli num_reads;
    ulli num_writes;

    ulli flush_time;
    ulli write_time;
    ulli read_time;
    ulli inst_time;

    ulli flush_cnt;
    ulli num_invalid;
} results;

typedef struct cache {
    //cache parameters
    uint block_size;
    uint log_of_blocksize;

    uint transfer_cycles;

    uint cache_size;
    uint assoc;
    uint hit_time;
    uint miss_time;
    uint transfer_time;
    uint bus_width;

    uint num_sets;
    uint tag_size;

    //cache set points to array of sets
    struct cache_set* cache_set;

    //must know where to go next if we get a miss
    struct cache* next_level;

    //main memory parameters
    uint mem_sendaddr;
    uint mem_ready;
    uint mem_chunktime;
    uint mem_chunksize;

    //keep track of hits and misses
    ull num_hits;
```

```
    ull num_misses;
    ull total_requests;

    double hit_rate;
    double miss_rate;

    ull kickouts;
    ull dirty_kickouts;
    ull transfers;
    ull flush_kickouts;
} cache;

//Cache set structure
typedef struct cache_set {
    struct cache_block* block;
    struct LRU* lru;
} cache_set;

typedef struct cache_block {
    ull tag;
    bool valid;
    bool dirty;
} cache_block;


//parse through the config file.
//Will store the values into the cache structs l1_data, l1_inst, l2, and main_mem
//these are all just properties of each of the caches and the main memory
int parse_config(char* filename, cache* l1_data, cache* l1_inst,
                 cache* l2, cache* main_mem);

void allocate_blocks(cache* l1_data, cache* l1_inst, cache* l2);

//loops through the traces and does the trace
void read_trace(cache* l1_data, cache* l1_inst, cache* l2,
                 results* cache_results);

uint search_cache(cache* cache_level, ul address, char type);

void look_through_cache(cache* cache_level,
                        ulli address, char type,
                        ulli num_bytes, ulli index);

ulli get_tag(cache* cache_level, ulli address);

ulli get_index(cache* cache_level, ulli address);

ulli get_byte_offset(cache* cache_level, ulli address);

ulli create_address(cache* cache_level, ulli tag, ulli index,
                        ulli byte_offset);

ulli prep_search_cache(cache* cache_level, ulli address,
                        int bytesize, char op);

int num_indices(cache* cache_level, ulli address, uint bytesize);

//outputs the results into a file
void report(cache* l1_data, cache* l1_inst, cache* l2,
               cache* main_mem, results* cache_results,
               char* outputFileName);

void print_cache(cache* cache_level, FILE * outputFile);

//Flushes the cache
```

```
uint flush(cache* cache_level);

//Transfer up or down a level
uint transfer(cache* cache_level);

void init_cache(cache* cache_level);

//Allocate a cache's contents
void cache_alloc(cache* cache_level);

void cache_dealloc(cache* cache_level);

static inline unsigned long int log_2(unsigned long int x)
{
    return (uint)round(log(x)/log(2));
}

#endif
```

CACHE.C

```
#include "cache.h"
#include "LRU.h"

int parse_config(char* filename, cache* l1_data, cache* l1_inst,
                 cache* l2, cache* main_mem){
    FILE *fp;
    char input[20];
    char cacheLevel[10];
    int val;
    fp = fopen(filename, "r");

    if(!fp){
        printf("File Don't Exist \n");
        fp = fopen("Config/default.dat", "r");

        if (!fp) return -1;
    }
    else{
        //read through the config file,
        //the config file is formatted so that we have
        // cacheLevel(string) property(string) value(integer)
        // repeated over new lines
        while (fscanf(fp,"%s %s %d\n",cacheLevel, input, &val) == 3){
            // printf("%s %s %d\n", cacheLevel, input, val);
            if(strcmp(cacheLevel, "L1") == 0){
                if (strcmp(input, "block_size")       == 0){
                    l1_data->block_size = val;
                    l1_inst->block_size = val;
                } else if (strcmp(input, "cache_size") == 0){
                    l1_data->cache_size = val;
                    l1_inst->cache_size = val;
                } else if (strcmp(input, "assoc")      == 0){
                    l1_data->assoc = val;
                    l1_inst->assoc = val;
                } else if (strcmp(input, "hit_time")   == 0){
                    l1_data->hit_time = val;
                    l1_inst->hit_time = val;
                } else if (strcmp(input, "miss_time")  == 0){
                    l1_data->miss_time = val;
                    l1_inst->miss_time = val;
                }
            } else if (strcmp(cacheLevel, "L2") == 0){
                if (strcmp(input, "block_size") == 0){
                    l2->block_size = val;
                } else if (strcmp(input, "cache_size")     == 0){
                    l2->cache_size = val;
                } else if (strcmp(input, "assoc")          == 0){
                    l2->assoc = val;
                } else if (strcmp(input, "hit_time")       == 0){
                    l2->hit_time = val;
                } else if (strcmp(input, "miss_time")      == 0){
                    l2->miss_time = val;
                } else if (strcmp(input, "transfer_time")  == 0){
                    l2->transfer_time = val;
                } else if (strcmp(input, "bus_width")      == 0){
                    l2->bus_width = val;
                }
            } else if (strcmp(cacheLevel, "mm") == 0){
                if (strcmp(input, "mem_sendaddr")          == 0){
                    main_mem->mem_sendaddr = val;
                } else if (strcmp(input, "mem_ready")      == 0){
                    main_mem->mem_ready = val;
```

```
            } else if (strcmp(input, "mem_chunktime")    == 0){
                main_mem->mem_chunktime = val;
            } else if (strcmp(input, "mem_chunksize")    == 0){
                main_mem->mem_chunksize = val;
            }
        }
    }



    l1_inst->bus_width = 4;
    l1_data->bus_width = 4;
    main_mem->bus_width = 0;

    uint address_length = 64;

    //Fully Associative
    if(l1_data->assoc == 0){
        l1_data->assoc = l1_data->cache_size / l1_data->block_size;
    }

    l1_data->num_sets = l1_data->cache_size /
                                (l1_data->assoc * l1_data->block_size);
    l1_data->tag_size = address_length - log_2(l1_data->num_sets)
                                       - log_2(l1_data->block_size);
    l1_data->next_level = l2;

    l1_data->log_of_blocksize = (log_2(l1_data->block_size));

    l1_data->transfer_cycles = transfer(l1_data);

    //Fully Associative
    if(l1_inst->assoc == 0){
        l1_inst->assoc = l1_inst->cache_size / l1_inst->block_size;
    }

    l1_inst->num_sets = l1_inst->cache_size /
                            (l1_inst->assoc * l1_inst->block_size);
    l1_inst->tag_size = address_length - log_2(l1_data->num_sets)
                                       - log_2(l1_inst->block_size);
    l1_inst->next_level = l2;

    l1_inst->log_of_blocksize = (log_2(l1_inst->block_size));

    l1_inst->transfer_cycles = transfer(l1_inst);

    //Fully Associative
    if(l2->assoc == 0){
        l2->assoc = l2->cache_size / l2->block_size;
    }

    l2->num_sets = l2->cache_size / (l2->assoc * l2->block_size);
    l2->tag_size = address_length - log_2(l2->num_sets)
                                  - log_2(l2->block_size);
    l2->next_level = main_mem;

    l2->log_of_blocksize = (log_2(l2->block_size));

    l2->transfer_cycles = transfer(l2);

    main_mem->next_level = NULL;
  }

  return 0;
}
```

```
void allocate_blocks(cache* l1_data, cache* l1_inst, cache* l2){
    cache_alloc(l1_data);
    cache_alloc(l1_inst);
    cache_alloc(l2);
}

void cache_alloc(cache* cache_level)
{
    cache_level->cache_set = malloc(cache_level->num_sets * sizeof(cache_set));
    uint i = 0;
    uint j = 0;

    //For every cache set, malloc all blocks
    for(i = 0; i < cache_level->num_sets; i++){
        //Construct an lru and return the pointer
        cache_level->cache_set[i].lru = LRU_Construct(cache_level->assoc);
        //Malloc the blocks at the index
        cache_level->cache_set[i].block =
                        malloc(cache_level->assoc * sizeof(cache_block));

        for (j = 0; j < cache_level->assoc; j++)
        {
            //Set the valid and dirty bits
            cache_level->cache_set[i].block[j].valid = 0;
            cache_level->cache_set[i].block[j].dirty = 0;
        }
    }
}

void cache_dealloc(cache* cache_level)
{
    uint i = 0;

    for(i = 0; i < cache_level->num_sets; i++){

        LRU_DeConstruct(cache_level->cache_set[i].lru);

        free(cache_level->cache_set[i].block);
    }
    free(cache_level->cache_set);

    free(cache_level);
}

//recreates the address
ulli create_address(cache* cache_level, ulli tag, ulli index, ulli byte_offset){
    ul address = 0;
    address |= (tag << (64 - cache_level->tag_size));
    address |= (index << cache_level->log_of_blocksize);
    address |= byte_offset;
    return address;
}

ulli prep_search_cache(cache* cache_level, ulli address, int bytesize, char op){
    ulli cycles = 0;
    ul word_size = 4;

    ul word_offset = address & (word_size - 1);

    bytesize += word_offset;

    while(bytesize > 0){
        cycles += search_cache(cache_level, address, op);
        address += word_size;
```

```
        bytesize -= word_size;
    }

    return cycles;
}

void read_trace(cache* l1_data, cache* l1_inst, cache* l2,
                results* cache_results){
    char op;
    ul address = 0;
    int bytesize = 0;
    ulli flush_num = 0;
    while(scanf("%c %lx %d\n", &op, &address, &bytesize) == 3){
        if(op == 'I'){
            flush_num++;
            cache_results->num_inst++;

            cache_results->inst_time += prep_search_cache(l1_inst,
                                                          address,
                                                          bytesize, op);
        } else if (op == 'R'){
            cache_results->num_reads++;
            cache_results->read_time += prep_search_cache(l1_data, address,
                                                          bytesize, op);
        } else if (op == 'W'){
            cache_results->num_writes++;
            cache_results->write_time += prep_search_cache(l1_data, address,
                                                          bytesize, op);
        }

        //write all dirty blocks to the next level of cache.
        //do this all the way down to main memory
        if(flush_num >= 380000){
            flush_num = 0;
            //Currently, this flushes l1_data, then l2,
            //then l1_inst, then l2
            cache_results->flush_time += flush(l1_data);
            cache_results->flush_time += flush(l1_inst); //invalidate all
            cache_results->flush_time += flush(l2);
            cache_results->flush_cnt++;
            cache_results->num_invalid++;
        }
    }
}

void init_cache(cache* cache_level){
    uint i;
    for (i = 0; i < cache_level->num_sets; i++)
    {
        uint j;
        for (j = 0; j < cache_level->assoc; j++){
            cache_level->cache_set[i].block[j].valid = false;
            cache_level->cache_set[i].block[j].dirty = false;
            cache_level->cache_set[i].block[j].tag   = 0;
        }
    }
}

uint flush(cache* cache_level)
{
    uint cycles = 0;

    uint i;
    for (i = 0; i < cache_level->num_sets; i++)
    {
```

```
        uint j;
        for (j = 0; j < cache_level->assoc; j++){
            if (cache_level->cache_set[i].block[j].dirty)
            {
                unsigned long dirty_addr = create_address(cache_level,
                                    cache_level->cache_set[i].block[j].tag,
                                    i, 0);
                cache_level->flush_kickouts++;

                cycles += cache_level->transfer_cycles;
                cycles += search_cache(cache_level->next_level, dirty_addr, 'W');
            }
            cache_level->cache_set[i].block[j].valid = false;
            cache_level->cache_set[i].block[j].dirty = false;
        }
    }

    return cycles;
}


//Return the number of cycles required to transfer a block downstream
uint transfer(cache* cache_level)
{
    uint cycles;

    //We are not going to main memory
    if (cache_level->next_level->bus_width)
    {
        cycles = cache_level->next_level->transfer_time
            * (cache_level->block_size / cache_level->next_level->bus_width);
    }
    else //We are going to main memory
    {
        cycles = cache_level->next_level->mem_sendaddr
                + cache_level->next_level->mem_ready
                + (cache_level->next_level->mem_chunktime
                    * (cache_level->block_size /
                        cache_level->next_level->mem_chunksize));
    }
    return cycles;
}

uint search_cache(cache* cache_level, ul address, char type){
    uint cycles = 0;

    if (cache_level->next_level != NULL){
        cache_level->total_requests++;
        ulli tag, index;//, byte_offset;
        tag         = get_tag(cache_level, address);
        index       = get_index(cache_level, address);
        // byte_offset = get_byte_offset(cache_level, address);
        //look for the tag in the cache
        for(uint i = 0; i < cache_level->assoc; i++){
            if(cache_level->cache_set[index].block[i].valid == true
                    && cache_level->cache_set[index].block[i].tag == tag){

                cache_level->num_hits++;
                //If its a write, make it dirty
                if(type == 'W'){
                    cache_level->cache_set[index].block[i].dirty = true;
                }
                LRU_Update(cache_level, index, i);
                cycles += cache_level->hit_time;
                return cycles;
```

```
            }
        }

        //didnt find in cache, it's a miss
        cache_level->num_misses = cache_level->num_misses + 1;

        //We know that we are going to have a read delay
        cycles += cache_level->miss_time;

        uint b = LRU_Get_LRU(cache_level, index);
        LRU_Update(cache_level, index, b);

        //check if we need to kickout
        if(cache_level->cache_set[index].block[b].valid == true){
            cache_level->kickouts++;

            //check if its dirty, push it through
            if(cache_level->cache_set[index].block[b].dirty == true){
                ulli dirty_addr = create_address(cache_level,
                                  cache_level->cache_set[index].block[b].tag,
                                  index, 0);
                cache_level->dirty_kickouts++;
                cycles += search_cache(cache_level->next_level, dirty_addr, 'W');
                cycles += cache_level->transfer_cycles;
            }
        }

        cycles += search_cache(cache_level->next_level, address, 'R');
        cycles += cache_level->transfer_cycles;
        //Going to need to transfer down a level because we missed

        //bring the stuff into this cache
        cache_level->cache_set[index].block[b].tag      = tag;
        cache_level->cache_set[index].block[b].valid    = true;

        if(type == 'W')
            cache_level->cache_set[index].block[b].dirty    = true;
        else
            cache_level->cache_set[index].block[b].dirty    = false;

    //We are in main memory
    }else{
       cache_level->num_hits = cache_level->num_hits + 1;
    }

    //Must also add hit time, "replay"
    cycles += cache_level->hit_time;
    return cycles;
}

ulli get_tag(cache* cache_level, ulli address){
    return (address >> (64 - cache_level->tag_size));
}

ulli get_index(cache* cache_level, ulli address){
    ulli index;
    index   = address << cache_level->tag_size;
    index   = index   >> (cache_level->tag_size);
    index   = index   >> cache_level->log_of_blocksize;
    return index;
}

ulli get_byte_offset(cache* cache_level, ulli address){
    ulli byte_offset;
    byte_offset = address << (64 - cache_level->log_of_blocksize);
```

```
    byte_offset = byte_offset >> (64 - cache_level->log_of_blocksize);
    return byte_offset;
}

//finds the number of indexes we need to use for a single instruction
int num_indices(cache* cache_level, ulli address, uint num_bytes){
    ulli byte_offset;
    byte_offset = get_byte_offset(cache_level, address);

    int num_blocks_requested = 1;
    int j = (byte_offset + num_bytes);
    while(j > cache_level->block_size){
        j = j - cache_level->block_size;
        num_blocks_requested++;
    }
    return num_blocks_requested;
}

void report(cache* l1_data, cache* l1_inst, cache* l2, cache* main_mem, results*
    cache_results, char* outputFileName){

    FILE * outputFile;

    outputFile = fopen(outputFileName, "wb");

    cache_results->inst_time += cache_results->flush_time;

    fprintf(outputFile, "-------------------------------------------------------------------------\n"
        );
    fprintf(outputFile, "%s          Simulation Results\n", outputFileName);
    fprintf(outputFile, "-------------------------------------------------------------------------\n\
        n");

    //Calculate the l1_inst things
    l1_inst->total_requests = l1_inst->num_hits + l1_inst->num_misses;
    l1_inst->hit_rate    =   (double) l1_inst->num_hits      /   l1_inst->total_requests
        * 100;
    l1_inst->miss_rate   =   (double) l1_inst->num_misses    /   l1_inst->total_requests
        * 100;
    l1_inst->transfers   =   l1_inst->num_misses + l1_inst->flush_kickouts;

    //Calculate the l1_data things
    l1_data->total_requests = l1_data->num_hits + l1_data->num_misses;
    l1_data->hit_rate    =   (double) l1_data->num_hits      /   l1_data->total_requests
        * 100;
    l1_data->miss_rate   =   (double) l1_data->num_misses    /   l1_data->total_requests
        * 100;
    l1_data->transfers   =   l1_data->num_misses + l1_data->flush_kickouts;

    //Calculate the l2 things
    l2->total_requests = l2->num_hits + l2->num_misses;
    l2->hit_rate         =   (double) l2->num_hits           /   l2->total_requests      *
        100;
    l2->miss_rate        =   (double) l2->num_misses         /   l2->total_requests      *
        100;
    l2->transfers        =   l2->num_misses + l2->flush_kickouts;

    ulli total_time = cache_results->read_time + cache_results->write_time + cache_results->
        inst_time;

    uint ICache_cost    = (l1_inst->cache_size / 4096)  * 100   + (l1_inst->cache_size /
        4096) * (uint)(log_2(l1_inst->assoc)) * 100;
    uint DCache_cost    = (l1_data->cache_size / 4096)  * 100   + (l1_data->cache_size /
        4096) * (uint)(log_2(l1_data->assoc)) * 100;
    uint L2_cache_cost  = (l2->cache_size / 32768)      * 50    + (l2->cache_size / 32768)
```

```
      * (uint)(log_2(l2->assoc))       * 50;
int main_mem_latency_factor = (log_2(main_mem->mem_chunksize)) - 3;
uint memory_cost     = 50 + 25 + main_mem_latency_factor * 100;

ulli exec_time = cache_results->inst_time + cache_results->read_time + cache_results->
    write_time +cache_results->flush_time;

//Calculate percent of reference types
ull total_traces        = cache_results->num_inst + cache_results->num_reads +
    cache_results->num_writes;
double inst_percent     = ((double)cache_results->num_inst      / (double)total_traces)
    * 100;
double read_precent     = ((double)cache_results->num_reads     / (double)total_traces)
    * 100;
double write_percent    = ((double)cache_results->num_writes    / (double)total_traces)
    * 100;

fprintf(outputFile, "Memory System: \n");
fprintf(outputFile, "   Dcache size = %u  :  ways = %u  :  block size = %u \n", l1_data
    ->cache_size, l1_data->assoc, l1_data->block_size);
fprintf(outputFile, "   Icache size = %u  :  ways = %u  :  block size = %u \n", l1_inst
    ->cache_size, l1_inst->assoc, l1_inst->block_size);
fprintf(outputFile, "   L2-cache size = %u  :  ways = %u  :  block size = %u \n", l2->
    cache_size, l2->assoc, l2->block_size);
fprintf(outputFile, "   Memory ready time = %u  :  chunksize = %u  :  chunktime = %u \n"
    , main_mem->mem_ready, main_mem->mem_chunksize, main_mem->mem_chunktime);
fprintf(outputFile, "\n");

fprintf(outputFile, "Execute time   =   %llu;       Total refs  = %llu\n", exec_time,
    total_traces);
fprintf(outputFile, "Flush time     =   %llu\n", cache_results->flush_time);
fprintf(outputFile, "Inst refs      =   %llu;   Data refs   = %llu\n", cache_results->
    num_inst , cache_results->num_reads + cache_results->num_writes );
fprintf(outputFile, "\n");

fprintf(outputFile, "Number of reference types :    [Percentage]\n");
fprintf(outputFile, "   Reads   =   %15llu      [%4.1f%%]\n", cache_results->num_reads,
       read_precent);
fprintf(outputFile, "   Writes  =   %15llu      [%4.1f%%]\n", cache_results->num_writes,
       write_percent);
fprintf(outputFile, "   Inst.   =   %15llu      [%4.1f%%]\n", cache_results->num_inst,
       inst_percent);
fprintf(outputFile, "   Total   =   %15llu\n ", total_traces);
fprintf(outputFile, "\n");

fprintf(outputFile, "Total cycles for activities:   [Percentage]\n");
fprintf(outputFile, "   Reads   =   %15llu      [%4.1f%%]\n", cache_results->read_time,
    ((double)cache_results->read_time / (double)(exec_time - cache_results->flush_time)
    * 100));
fprintf(outputFile, "   Writes  =   %15llu      [%4.1f%%]\n", cache_results->write_time,
     ((double)cache_results->write_time / (double)(exec_time - cache_results->flush_time
    ) * 100));
fprintf(outputFile, "   Inst.   =   %15llu      [%4.1f%%]\n", cache_results->inst_time,
    ((double)cache_results->inst_time / (double)(exec_time - cache_results->flush_time)
    * 100));
fprintf(outputFile, "   Total   =   %15llu\n ", total_time);
fprintf(outputFile, "\n");

fprintf(outputFile, "Average cycles per activity:\n");
fprintf(outputFile, "   Read = %.1f; Write = %.1f; Inst. = %.1f\n", ((double)
    cache_results->read_time / (double)cache_results->num_reads), ((double)cache_results
    ->write_time / (double)cache_results->num_writes), ((double)total_time / (double)
    cache_results->num_inst));
fprintf(outputFile, "Ideal: Exec. Time = %llu; CPI = %.1f\n", total_traces +
    cache_results->num_inst, round(10*(((double)total_traces + (double)cache_results->
```

```
        num_inst)/ (double)cache_results->num_inst))/10);
    fprintf(outputFile, "Ideal mis-aligned: Exec. Time = %llu; CPI = %.1f\n", l1_inst->
        total_requests + l1_data->total_requests + cache_results->num_inst, round(10*((
        double)l1_inst->total_requests + (double)l1_data->total_requests + (double)
        cache_results->num_inst)/ (double)cache_results->num_inst)/10);
    fprintf(outputFile, "\n");

    fprintf(outputFile, "Memory Level:  L1i\n");
    fprintf(outputFile, "   Hit Count = %llu         Miss Count = %llu\n", l1_inst->num_hits,
         l1_inst->num_misses);
    fprintf(outputFile, "   Total Requests = %llu\n", l1_inst->total_requests);
    fprintf(outputFile, "   Hit Rate = %.1f%%   Miss Rate = %.1f%%\n", l1_inst->hit_rate,
        l1_inst->miss_rate);
    fprintf(outputFile, "   Kickouts = %llu; Dirty Kickouts = %llu; Transfers = %llu\n",
        l1_inst->kickouts, l1_inst->dirty_kickouts, l1_inst->transfers);
    fprintf(outputFile, "Flush Kickouts = %llu\n", l1_inst->flush_kickouts);
    fprintf(outputFile, "\n");

    fprintf(outputFile, "Memory Level:  L1d\n");
    fprintf(outputFile, "   Hit Count = %llu         Miss Count = %llu\n", l1_data->num_hits,
         l1_data->num_misses);
    fprintf(outputFile, "   Total Requests = %llu\n", l1_data->total_requests);
    fprintf(outputFile, "   Hit Rate = %.1f%%   Miss Rate = %.1f%%\n", l1_data->hit_rate,
        l1_data->miss_rate);
    fprintf(outputFile, "   Kickouts = %llu; Dirty Kickouts = %llu; Transfers = %llu\n",
        l1_data->kickouts, l1_data->dirty_kickouts, l1_data->transfers);
    fprintf(outputFile, "Flush Kickouts = %llu\n", l1_data->flush_kickouts);
    fprintf(outputFile, "\n");

    fprintf(outputFile, "Memory Level:  L2\n");
    fprintf(outputFile, "   Hit Count = %llu         Miss Count = %llu\n", l2->num_hits, l2->
        num_misses);
    fprintf(outputFile, "   Total Requests = %llu\n", l2->total_requests);
    fprintf(outputFile, "   Hit Rate = %.1f%%   Miss Rate = %.1f%%\n", l2->hit_rate, l2->
        miss_rate);
    fprintf(outputFile, "   Kickouts = %llu; Dirty Kickouts = %llu; Transfers = %llu\n", l2
        ->kickouts, l2->dirty_kickouts, l2->transfers);
    fprintf(outputFile, "Flush Kickouts = %llu\n", l2->flush_kickouts);
    fprintf(outputFile, "\n");

    fprintf(outputFile, "L1 cache cost (Icache $%d) + (Dcache $%d) = $%d\n", ICache_cost,
        DCache_cost, ICache_cost + DCache_cost);
    fprintf(outputFile, "L2 cache cost = $%d; Memory cost = $%d; Total cost = $%d\n",
        L2_cache_cost, memory_cost, ICache_cost + DCache_cost + L2_cache_cost + memory_cost)
        ;
    fprintf(outputFile, "Flushes = %llu   :  Invalidates = %llu\n", cache_results->flush_cnt,
         cache_results->num_invalid);
    fprintf(outputFile, "\n");

    fclose(outputFile);
}

void print_cache(cache* cache_level, FILE * outputFile){
    for(ulli i = 0; i < cache_level->num_sets; i++){
        if(cache_level->cache_set[i].block[0].valid == true){
            fprintf(outputFile, "Index: %4llx | V:1 D:%d Tag: %12llx | ", i, cache_level->
                cache_set[i].block[0].dirty, cache_level->cache_set[i].block[0].tag);
            for(ulli j = 1; j < cache_level->assoc; j++){
                if(cache_level->cache_set[i].block[j].valid == true){
                    fprintf(outputFile,  "V:%d D:%d Tag: %12llx | ", cache_level->cache_set[
                        i].block[j].valid, cache_level->cache_set[i].block[j].dirty,
                        cache_level->cache_set[i].block[j].tag);
                }
                else if(cache_level->cache_set[i].block[j].valid == false){
                    fprintf(outputFile,  "V:%d D:%d Tag: %12c | ", cache_level->cache_set[i
```

```
                        ].block[j].valid, cache_level->cache_set[i].block[j].dirty, '-');
                    }
                }
                fprintf(outputFile, "\n");
            }
        }
        fprintf(outputFile, "\n");
}
```

LRU.H

```
#ifndef LRU_H
#define LRU_H
#include "cache.h"

typedef struct node {
    struct node* next;
    unsigned int index;
} node;

typedef struct LRU {
    struct node* head;
} LRU;

// Initializes an LRU structure to hold the least recently used block
LRU* LRU_Construct(unsigned int num_block);

//reorganizes the LRU to put the least recently used block at the top and return that node
node* LRU_Update(cache* cache_level, uint set, uint block);

unsigned int LRU_Get_LRU(cache* cache_level, uint set);

void LRU_DeConstruct(LRU* lru);

void print_lru(cache* cache_level, uint set);
#endif
```

LRU.c

```
//LRU Linked List
#include "LRU.h"
#include <stdio.h>
#include <stdlib.h>

LRU* LRU_Construct(unsigned int num_block)
{

    if (num_block)
    {
        LRU* lru = malloc( sizeof(struct LRU));
        node* n_ptr = NULL;
        n_ptr = malloc(num_block * sizeof(struct node));
        lru->head = n_ptr;
        for (uint i = 0; i < num_block; i++)
        {
            n_ptr->index = num_block - 1 - i;
            n_ptr->next = NULL;
            if(i) {
                node* l_ptr = n_ptr;
                l_ptr--;
                l_ptr->next = n_ptr;
            }
            n_ptr++;
        }

        return lru;
    }
    return NULL;
}

node* LRU_Update(cache* cache_level, uint set, uint block){
    if (block > cache_level->assoc)
    {
        printf("Block index exceeds associativity: ERROR");
        return NULL;
    }

    struct node* cur_ptr;
    struct node* i_ptr;

    //Set the pointer equal to the head
    cur_ptr = cache_level->cache_set[set].lru->head;

    //Check for single element list, or if the way is already most recently used

    if (!cur_ptr->next || cur_ptr->index == block) return cur_ptr;

    //Stop when cur_ptr is equal to the prior element than the block
    while(cur_ptr->next && cur_ptr->next->index != block)
    {
        //Move on to the next element
        cur_ptr = cur_ptr->next;
    }

    //i_ptr becomes a pointer to the block that needs to be moved to the top
    i_ptr = cur_ptr->next;
    //If we are not at the final element, we should link cur_ptr to the element after i_ptr
    if (cur_ptr->next->next != NULL)
    {
        //The next pointer should skip i_ptr
        cur_ptr->next = cur_ptr->next->next;
```

```
    }
    else{
        cur_ptr->next = NULL;
    }

    //Point i_ptr to the current head
    i_ptr->next = cache_level->cache_set[set].lru->head;

    //Link the head to i_ptr
    cache_level->cache_set[set].lru->head = i_ptr;

    return i_ptr;
}

unsigned int LRU_Get_LRU(cache* cache_level, uint set)
{
    struct node* cur_ptr = cache_level->cache_set[set].lru->head;
    while (cur_ptr->next != NULL)
    {
        cur_ptr = cur_ptr->next;
    }
    return cur_ptr->index;
}

void LRU_DeConstruct(LRU* lru)
{
    node* n_ptr = lru->head;
    node* l_ptr = n_ptr;
    while (n_ptr->next)
    {
        l_ptr = n_ptr;
        n_ptr = n_ptr->next;
        free(l_ptr);
    }

    free(n_ptr);

    free(lru);
}

void print_lru(cache* cache_level, uint set){
    struct node* cur_ptr = cache_level->cache_set[set].lru->head;
    while (cur_ptr->next != NULL)
    {
        printf("%u  ", cur_ptr->index);
        cur_ptr = cur_ptr->next;
    }
    printf("%u  ", cur_ptr->index);
    printf("\n");
}
```

MAKEFILE

```
main.o : main.c cache.c LRU.c
	gcc -std=c99 -Wall -O3 -o main.o main.c cache.c LRU.c -lm

clean:
	rm main.o
	gcc -std=c99 -Wall -O3 -o main.o main.c cache.c LRU.c -lm
```

```
------------------------------------------------------------
bzip2_All_2way.dat Simulation Results
------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 2  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 52170531595; Total refs = 10000000073
Flush time  = 391982254
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      20125897745      [38.9%]
Writes  =      19101145576      [36.9%]
Inst.  =      12551506020      [24.2%]
Total  =      51778549341

Average cycles per activity:
Read = 10.7; Write = 34.6; Inst. = 6.8
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527121  Miss Count = 555401
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2674; Dirty Kickouts = 0; Transfers = 555401
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2378127911  Miss Count = 160072485
Total Requests = 2538200396
  Hit Rate = 93.7%  Miss Rate = 6.3%
Kickouts = 154979866; Dirty Kickouts = 62473522; Transfers = 161308323
Flush Kickouts = 1235838

Memory Level:  L2
Hit Count = 77722205  Miss Count = 146615041
Total Requests = 224337246
  Hit Rate = 34.6%  Miss Rate = 65.4%
Kickouts = 136811655; Dirty Kickouts = 55034618; Transfers = 148667098
Flush Kickouts = 2052057

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 19908  :  Invalidates = 19908
```

```
---------------------------------------------------------------
bzip2_All_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 4  :  block size = 32
Icache size = 8192  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 51846279658; Total refs = 10000000073
Flush time  = 385753270
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      19734976073      [38.3%]
Writes  =      19180835430      [37.3%]
Inst.  =      12544714885      [24.4%]
Total  =      51460526388

Average cycles per activity:
Read = 10.5; Write = 34.7; Inst. = 6.8
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527306  Miss Count = 555216
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 1778; Dirty Kickouts = 0; Transfers = 555216
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2380037622  Miss Count = 158162774
Total Requests = 2538200396
  Hit Rate = 93.8%  Miss Rate = 6.2%
Kickouts = 153066463; Dirty Kickouts = 61597513; Transfers = 159395041
Flush Kickouts = 1232267

Memory Level:  L2
Hit Count = 75870220  Miss Count = 145677550
Total Requests = 221547770
  Hit Rate = 34.2%  Miss Rate = 65.8%
Kickouts = 135799759; Dirty Kickouts = 54270395; Transfers = 147758143
Flush Kickouts = 2080593

L1 cache cost (Icache $600) + (Dcache $600) = $1200
L2 cache cost = $150; Memory cost = $75; Total cost = $1425
Flushes = 19908  :  Invalidates = 19908
```

```
-----------------------------------------------------------------
bzip2_All_FA_L2big.dat Simulation Results
-----------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 65536  :  ways = 1024  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 48012706190; Total refs = 10000000073
Flush time  = 582674222
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      17998338985      [37.9%]
Writes  =      16690474845      [35.2%]
Inst.  =      12741218138      [26.9%]
Total  =      47430031968

Average cycles per activity:
Read = 9.6; Write = 30.2; Inst. = 6.3
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527363  Miss Count = 555159
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 1619; Dirty Kickouts = 0; Transfers = 555159
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2380877774  Miss Count = 157322622
Total Requests = 2538200396
  Hit Rate = 93.8%  Miss Rate = 6.2%
Kickouts = 152225918; Dirty Kickouts = 61293922; Transfers = 158531019
Flush Kickouts = 1208397

Memory Level:  L2
Hit Count = 97071253  Miss Count = 123308847
Total Requests = 220380100
  Hit Rate = 44.0%  Miss Rate = 56.0%
Kickouts = 104293877; Dirty Kickouts = 51137948; Transfers = 126793351
Flush Kickouts = 3484504

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $1100; Memory cost = $75; Total cost = $4775
Flushes = 19908  :  Invalidates = 19908
```

```
-------------------------------------------------------------------
bzip2_All_FA.dat Simulation Results
-------------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 32768  :  ways = 512  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 48769196313; Total refs = 10000000073
Flush time  = 356597532
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      18850904296      [38.9%]
Writes  =      17046226134      [35.2%]
Inst.  =      12515468351      [25.9%]
Total  =      48412598781

Average cycles per activity:
Read = 10.0; Write = 30.9; Inst. = 6.4
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527363  Miss Count = 555159
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 1619; Dirty Kickouts = 0; Transfers = 555159
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2380877774  Miss Count = 157322622
Total Requests = 2538200396
  Hit Rate = 93.8%  Miss Rate = 6.2%
Kickouts = 152225918; Dirty Kickouts = 61293922; Transfers = 158531019
Flush Kickouts = 1208397

Memory Level:  L2
Hit Count = 92347994  Miss Count = 128032106
Total Requests = 220380100
  Hit Rate = 41.9%  Miss Rate = 58.1%
Kickouts = 118091884; Dirty Kickouts = 53783400; Transfers = 130082299
Flush Kickouts = 2050193

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $500; Memory cost = $75; Total cost = $4175
Flushes = 19908  :  Invalidates = 19908
```

```
------------------------------------------------------------------
bzip2_defaults.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 53561312664; Total refs = 10000000073
Flush time  = 386727764
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      21895048990      [41.2%]
Writes  =      18718145246      [35.2%]
Inst.  =      12561390664      [23.6%]
Total  =      53174584900

Average cycles per activity:
Read = 11.6; Write = 33.9; Inst. = 7.0
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12094754630  Miss Count = 1327892
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 782784; Dirty Kickouts = 0; Transfers = 1327892
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2360100410  Miss Count = 178099986
Total Requests = 2538200396
  Hit Rate = 93.0%  Miss Rate = 7.0%
Kickouts = 173028492; Dirty Kickouts = 69160663; Transfers = 179312231
Flush Kickouts = 1212245

Memory Level:  L2
Hit Count = 99842764  Miss Count = 149958022
Total Requests = 249800786
  Hit Rate = 40.0%  Miss Rate = 60.0%
Kickouts = 140327614; Dirty Kickouts = 57867455; Transfers = 151908521
Flush Kickouts = 1950499

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $75; Total cost = $525
Flushes = 19908  :  Invalidates = 19908
```

```
---------------------------------------------------------------
bzip2_L1_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 53792271746; Total refs = 10000000073
Flush time  = 413353232
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      20850535313      [39.1%]
Writes  =      19954452414      [37.4%]
Inst.  =      12573930787      [23.6%]
Total  =      53378918514

Average cycles per activity:
Read = 11.1; Write = 36.1; Inst. = 7.1
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527121  Miss Count = 555401
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2674; Dirty Kickouts = 0; Transfers = 555401
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2378127911  Miss Count = 160072485
Total Requests = 2538200396
  Hit Rate = 93.7%  Miss Rate = 6.3%
Kickouts = 154979866; Dirty Kickouts = 62473522; Transfers = 161308323
Flush Kickouts = 1235838

Memory Level:  L2
Hit Count = 69100346  Miss Count = 155236900
Total Requests = 224337246
  Hit Rate = 30.8%  Miss Rate = 69.2%
Kickouts = 145606492; Dirty Kickouts = 56091613; Transfers = 157235204
Flush Kickouts = 1998304

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $50; Memory cost = $75; Total cost = $925
Flushes = 19908  :  Invalidates = 19908
```

```
-----------------------------------------------------------------
bzip2_L1_8way.dat Simulation Results
-----------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 8  :  block size = 32
Icache size = 8192  :  ways = 8  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 54404036928; Total refs = 10000000073
Flush time  = 423996543
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      20481618899      [37.9%]
Writes  =      20913975750      [38.7%]
Inst.  =      12584445736      [23.3%]
Total  =      53980040385

Average cycles per activity:
Read = 10.9; Write = 37.9; Inst. = 7.1
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527356  Miss Count = 555166
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 1662; Dirty Kickouts = 0; Transfers = 555166
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2380527294  Miss Count = 157673102
Total Requests = 2538200396
  Hit Rate = 93.8%  Miss Rate = 6.2%
Kickouts = 152576404; Dirty Kickouts = 61411716; Transfers = 158893681
Flush Kickouts = 1220579

Memory Level:  L2
Hit Count = 60944661  Miss Count = 159915902
Total Requests = 220860563
  Hit Rate = 27.6%  Miss Rate = 72.4%
Kickouts = 150285494; Dirty Kickouts = 55300925; Transfers = 161919134
Flush Kickouts = 2003232

L1 cache cost (Icache $800) + (Dcache $800) = $1600
L2 cache cost = $50; Memory cost = $75; Total cost = $1725
Flushes = 19908  :  Invalidates = 19908
```

```
---------------------------------------------------------------
bzip2_L1_small_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 4  :  block size = 32
Icache size = 4096  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 52523407207; Total refs = 10000000073
Flush time  = 342892157
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      20419942538      [39.1%]
Writes  =      19255855327      [36.9%]
Inst.  =      12504717185      [24.0%]
Total  =      52180515050

Average cycles per activity:
Read = 10.8; Write = 34.9; Inst. = 6.9
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095521667  Miss Count = 560855
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 14688; Dirty Kickouts = 0; Transfers = 560855
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2371554001  Miss Count = 166646395
Total Requests = 2538200396
  Hit Rate = 93.4%  Miss Rate = 6.6%
Kickouts = 164098043; Dirty Kickouts = 65157952; Transfers = 167302934
Flush Kickouts = 656539

Memory Level:  L2
Hit Count = 85319060  Miss Count = 147702681
Total Requests = 233021741
  Hit Rate = 36.6%  Miss Rate = 63.4%
Kickouts = 138072273; Dirty Kickouts = 55700360; Transfers = 149610765
Flush Kickouts = 1908084

L1 cache cost (Icache $300) + (Dcache $300) = $600
L2 cache cost = $50; Memory cost = $75; Total cost = $725
Flushes = 19908  :  Invalidates = 19908
```

```
------------------------------------------------------------------
bzip2_L1_small.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 1  :  block size = 32
Icache size = 4096  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 52917794978; Total refs = 10000000073
Flush time  = 326624950
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      21895601747      [41.6%]
Writes  =      18192564325      [34.6%]
Inst.  =      12503003956      [23.8%]
Total  =      52591170028

Average cycles per activity:
Read = 11.6; Write = 32.9; Inst. = 7.0
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12094746128  Miss Count = 1336394
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 795936; Dirty Kickouts = 0; Transfers = 1336394
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2335018951  Miss Count = 203181445
Total Requests = 2538200396
  Hit Rate = 92.0%  Miss Rate = 8.0%
Kickouts = 200633399; Dirty Kickouts = 78562930; Transfers = 203824843
Flush Kickouts = 643398

Memory Level:  L2
Hit Count = 139961829  Miss Count = 143762338
Total Requests = 283724167
  Hit Rate = 49.3%  Miss Rate = 50.7%
Kickouts = 134131930; Dirty Kickouts = 57422942; Transfers = 145640623
Flush Kickouts = 1878285

L1 cache cost (Icache $100) + (Dcache $100) = $200
L2 cache cost = $50; Memory cost = $75; Total cost = $325
Flushes = 19908  :  Invalidates = 19908
```

```
---------------------------------------------------------------
bzip2_L2_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 51004296206; Total refs = 10000000073
Flush time  = 377034627
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      19733728397      [39.0%]
Writes  =      18357491690      [36.3%]
Inst.  =      12536041492      [24.8%]
Total  =      50627261579

Average cycles per activity:
Read = 10.5; Write = 33.2; Inst. = 6.7
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527121  Miss Count = 555401
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2674; Dirty Kickouts = 0; Transfers = 555401
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2378127911  Miss Count = 160072485
Total Requests = 2538200396
  Hit Rate = 93.7%  Miss Rate = 6.3%
Kickouts = 154979866; Dirty Kickouts = 62473522; Transfers = 161308323
Flush Kickouts = 1235838

Memory Level:  L2
Hit Count = 84022331  Miss Count = 140314915
Total Requests = 224337246
  Hit Rate = 37.5%  Miss Rate = 62.5%
Kickouts = 130437124; Dirty Kickouts = 54399060; Transfers = 142382738
Flush Kickouts = 2067823

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $150; Memory cost = $75; Total cost = $1025
Flushes = 19908  :  Invalidates = 19908
```

```
------------------------------------------------------------------
bzip2_L2_big.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 65536  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 51139234694; Total refs = 10000000073
Flush time  = 614758798
Inst refs  = 7565217787;  Data refs  = 2434782286

Number of reference types :  [Percentage]
Reads  =       1882275327      [18.8%]
Writes  =        552506959      [ 5.5%]
Inst.  =       7565217787     [75.7%]
Total  =      10000000073

Total cycles for activities:  [Percentage]
Reads  =      19420268992      [38.4%]
Writes  =      18329566826      [36.3%]
Inst.  =      12774640078      [25.3%]
Total  =      50524475896

Average cycles per activity:
Read = 10.3; Write = 33.2; Inst. = 6.7
Ideal: Exec. Time = 17565217860; CPI = 2.3
Ideal mis-aligned: Exec. Time = 22199500705; CPI = 2.9

Memory Level:  L1i
Hit Count = 12095527121  Miss Count = 555401
Total Requests = 12096082522
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2674; Dirty Kickouts = 0; Transfers = 555401
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2378127911  Miss Count = 160072485
Total Requests = 2538200396
  Hit Rate = 93.7%  Miss Rate = 6.3%
Kickouts = 154979866; Dirty Kickouts = 62473522; Transfers = 161308323
Flush Kickouts = 1235838

Memory Level:  L2
Hit Count = 84347440  Miss Count = 139989806
Total Requests = 224337246
  Hit Rate = 37.6%  Miss Rate = 62.4%
Kickouts = 121763856; Dirty Kickouts = 52709541; Transfers = 143444070
Flush Kickouts = 3454264

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 19908  :  Invalidates = 19908
```

```
---------------------------------------------------------------
h264ref_All_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 2  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 27112120331; Total refs = 10000000106
Flush time  = 460689007
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =       9273316723      [34.8%]
Writes  =       2620034214      [ 9.8%]
Inst.  =      14758080387      [55.4%]
Total  =      26651431324

Average cycles per activity:
Read = 3.4; Write = 4.5; Inst. = 4.0
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11160285566  Miss Count = 47791322
Total Requests = 11208076888
  Hit Rate = 99.6%  Miss Rate = 0.4%
Kickouts = 44719492; Dirty Kickouts = 0; Transfers = 47791322
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3940990857  Miss Count = 83744469
Total Requests = 4024735326
  Hit Rate = 97.9%  Miss Rate = 2.1%
Kickouts = 79223864; Dirty Kickouts = 20672723; Transfers = 85239755
Flush Kickouts = 1495286

Memory Level:  L2
Hit Count = 108531583  Miss Count = 45172217
Total Requests = 153703800
  Hit Rate = 70.6%  Miss Rate = 29.4%
Kickouts = 37062689; Dirty Kickouts = 6420098; Transfers = 47738157
Flush Kickouts = 2565940

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 17710  :  Invalidates = 17710
```

```
---------------------------------------------------------------
h264ref_All_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 4  :  block size = 32
Icache size = 8192  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 25335616586; Total refs = 10000000106
Flush time  = 463915104
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =       8151351391      [32.8%]
Writes  =       2452092271      [ 9.9%]
Inst.  =      14268257820      [57.4%]
Total  =      24871701482

Average cycles per activity:
Read = 3.0; Write = 4.2; Inst. = 3.7
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11159355699  Miss Count = 48721189
Total Requests = 11208076888
  Hit Rate = 99.6%  Miss Rate = 0.4%
Kickouts = 45599000; Dirty Kickouts = 0; Transfers = 48721189
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3962032699  Miss Count = 62702627
Total Requests = 4024735326
  Hit Rate = 98.4%  Miss Rate = 1.6%
Kickouts = 58175096; Dirty Kickouts = 15514970; Transfers = 64160586
Flush Kickouts = 1457959

Memory Level:  L2
Hit Count = 90182134  Miss Count = 38214611
Total Requests = 128396745
  Hit Rate = 70.2%  Miss Rate = 29.8%
Kickouts = 29865258; Dirty Kickouts = 5001102; Transfers = 40836473
Flush Kickouts = 2621862

L1 cache cost (Icache $600) + (Dcache $600) = $1200
L2 cache cost = $150; Memory cost = $75; Total cost = $1425
Flushes = 17710  :  Invalidates = 17710
```

```
------------------------------------------------------------------
h264ref_All_FA_L2big.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 65536  :  ways = 1024  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 23224833703; Total refs = 10000000106
Flush time  = 634993545
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =       6977778138      [30.9%]
Writes  =       2107720234      [ 9.3%]
Inst.  =      13504341786      [59.8%]
Total  =      22589840158

Average cycles per activity:
Read = 2.6; Write = 3.6; Inst. = 3.4
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11151277315  Miss Count = 56799573
Total Requests = 11208076888
  Hit Rate = 99.5%  Miss Rate = 0.5%
Kickouts = 53642588; Dirty Kickouts = 0; Transfers = 56799573
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3968992020  Miss Count = 55743306
Total Requests = 4024735326
  Hit Rate = 98.6%  Miss Rate = 1.4%
Kickouts = 51209295; Dirty Kickouts = 13315680; Transfers = 57201073
Flush Kickouts = 1457767

Memory Level:  L2
Hit Count = 101221101  Miss Count = 26095225
Total Requests = 127316326
  Hit Rate = 79.5%  Miss Rate = 20.5%
Kickouts = 11583340; Dirty Kickouts = 2284377; Transfers = 29916083
Flush Kickouts = 3820858

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $1100; Memory cost = $75; Total cost = $4775
Flushes = 17710  :  Invalidates = 17710
```

```
-----------------------------------------------------------------
h264ref_All_FA.dat Simulation Results
-----------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 32768  :  ways = 512  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 24172730941; Total refs = 10000000106
Flush time  = 461490401
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =       7719133381      [32.6%]
Writes  =       2287924120      [ 9.6%]
Inst.  =      13704183039      [57.8%]
Total  =      23711240540

Average cycles per activity:
Read = 2.9; Write = 3.9; Inst. = 3.5
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11151277315  Miss Count = 56799573
Total Requests = 11208076888
  Hit Rate = 99.5%  Miss Rate = 0.5%
Kickouts = 53642588; Dirty Kickouts = 0; Transfers = 56799573
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3968992020  Miss Count = 55743306
Total Requests = 4024735326
  Hit Rate = 98.6%  Miss Rate = 1.4%
Kickouts = 51209295; Dirty Kickouts = 13315680; Transfers = 57201073
Flush Kickouts = 1457767

Memory Level:  L2
Hit Count = 95100155  Miss Count = 32216171
Total Requests = 127316326
  Hit Rate = 74.7%  Miss Rate = 25.3%
Kickouts = 23685862; Dirty Kickouts = 4087854; Transfers = 34853567
Flush Kickouts = 2637396

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $500; Memory cost = $75; Total cost = $4175
Flushes = 17710  :  Invalidates = 17710
```

```
---------------------------------------------------------------
h264ref_defaults.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 35147563146; Total refs = 10000000106
Flush time  = 414876381
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =      14922442972      [43.0%]
Writes  =       3968790793      [11.4%]
Inst.  =      15841453000      [45.6%]
Total  =      34732686765

Average cycles per activity:
Read = 5.5; Write = 6.8; Inst. = 5.2
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11154941079  Miss Count = 53135809
Total Requests = 11208076888
  Hit Rate = 99.5%  Miss Rate = 0.5%
Kickouts = 50182354; Dirty Kickouts = 0; Transfers = 53135809
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3856443351  Miss Count = 168291975
Total Requests = 4024735326
  Hit Rate = 95.8%  Miss Rate = 4.2%
Kickouts = 163794819; Dirty Kickouts = 43415363; Transfers = 169848153
Flush Kickouts = 1556178

Memory Level:  L2
Hit Count = 190005209  Miss Count = 76394116
Total Requests = 266399325
  Hit Rate = 71.3%  Miss Rate = 28.7%
Kickouts = 68826800; Dirty Kickouts = 13531572; Transfers = 78641541
Flush Kickouts = 2247425

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $75; Total cost = $525
Flushes = 17710  :  Invalidates = 17710
```

```
---------------------------------------------------------------
h264ref_L1_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 29195493490; Total refs = 10000000106
Flush time  = 452012225
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =      10406613203      [36.2%]
Writes  =       3080549312      [10.7%]
Inst.  =      15256318750      [53.1%]
Total  =      28743481265

Average cycles per activity:
Read = 3.9; Write = 5.3; Inst. = 4.3
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11160285566  Miss Count = 47791322
Total Requests = 11208076888
  Hit Rate = 99.6%  Miss Rate = 0.4%
Kickouts = 44719492; Dirty Kickouts = 0; Transfers = 47791322
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3940990857  Miss Count = 83744469
Total Requests = 4024735326
  Hit Rate = 97.9%  Miss Rate = 2.1%
Kickouts = 79223864; Dirty Kickouts = 20672723; Transfers = 85239755
Flush Kickouts = 1495286

Memory Level:  L2
Hit Count = 98283900  Miss Count = 55419900
Total Requests = 153703800
  Hit Rate = 63.9%  Miss Rate = 36.1%
Kickouts = 47852584; Dirty Kickouts = 9015275; Transfers = 57769956
Flush Kickouts = 2350056

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $50; Memory cost = $75; Total cost = $925
Flushes = 17710  :  Invalidates = 17710
```

```
-----------------------------------------------------------------
h264ref_L1_8way.dat Simulation Results
-----------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 8  :  block size = 32
Icache size = 8192  :  ways = 8  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 26897437126; Total refs = 10000000106
Flush time  = 470527393
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =       8738461787      [33.1%]
Writes  =       2486986995      [ 9.4%]
Inst.  =      15201460951      [57.5%]
Total  =      26426909733

Average cycles per activity:
Read = 3.2; Write = 4.3; Inst. = 3.9
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11156202045  Miss Count = 51874843
Total Requests = 11208076888
  Hit Rate = 99.5%  Miss Rate = 0.5%
Kickouts = 48728875; Dirty Kickouts = 0; Transfers = 51874843
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3967117006  Miss Count = 57618320
Total Requests = 4024735326
  Hit Rate = 98.6%  Miss Rate = 1.4%
Kickouts = 53087007; Dirty Kickouts = 13905536; Transfers = 59054280
Flush Kickouts = 1435960

Memory Level:  L2
Hit Count = 77848626  Miss Count = 46986033
Total Requests = 124834659
  Hit Rate = 62.4%  Miss Rate = 37.6%
Kickouts = 39418717; Dirty Kickouts = 6132867; Transfers = 49387022
Flush Kickouts = 2400989

L1 cache cost (Icache $800) + (Dcache $800) = $1600
L2 cache cost = $50; Memory cost = $75; Total cost = $1725
Flushes = 17710  :  Invalidates = 17710
```

```
------------------------------------------------------------------
h264ref_L1_small_4way.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 4  :  block size = 32
Icache size = 4096  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 31722053479; Total refs = 10000000106
Flush time  = 369448241
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =      11583795195      [36.9%]
Writes  =       3274434243      [10.4%]
Inst.  =      16494375800      [52.6%]
Total  =      31352605238

Average cycles per activity:
Read = 4.3; Write = 5.6; Inst. = 4.7
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11142436561  Miss Count = 65640327
Total Requests = 11208076888
  Hit Rate = 99.4%  Miss Rate = 0.6%
Kickouts = 63953917; Dirty Kickouts = 0; Transfers = 65640327
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3902136074  Miss Count = 122599252
Total Requests = 4024735326
  Hit Rate = 97.0%  Miss Rate = 3.0%
Kickouts = 120332251; Dirty Kickouts = 28040657; Transfers = 123209082
Flush Kickouts = 609830

Memory Level:  L2
Hit Count = 153586401  Miss Count = 63303665
Total Requests = 216890066
  Hit Rate = 70.8%  Miss Rate = 29.2%
Kickouts = 55736349; Dirty Kickouts = 11028062; Transfers = 65441168
Flush Kickouts = 2137503

L1 cache cost (Icache $300) + (Dcache $300) = $600
L2 cache cost = $50; Memory cost = $75; Total cost = $725
Flushes = 17710  :  Invalidates = 17710
```

```
---------------------------------------------------------------
h264ref_L1_small.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 1  :  block size = 32
Icache size = 4096  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 38570299603; Total refs = 10000000106
Flush time  = 359940805
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =      16703397888      [43.7%]
Writes  =       4433243116      [11.6%]
Inst.  =      17073717794      [44.7%]
Total  =      38210358798

Average cycles per activity:
Read = 6.2; Write = 7.6; Inst. = 5.7
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11122010646  Miss Count = 86066242
Total Requests = 11208076888
  Hit Rate = 99.2%  Miss Rate = 0.8%
Kickouts = 84402310; Dirty Kickouts = 0; Transfers = 86066242
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3767873369  Miss Count = 256861957
Total Requests = 4024735326
  Hit Rate = 93.6%  Miss Rate = 6.4%
Kickouts = 254596737; Dirty Kickouts = 65962984; Transfers = 257514997
Flush Kickouts = 653040

Memory Level:  L2
Hit Count = 327113983  Miss Count = 82430240
Total Requests = 409544223
  Hit Rate = 79.9%  Miss Rate = 20.1%
Kickouts = 74862924; Dirty Kickouts = 14915669; Transfers = 84549602
Flush Kickouts = 2119362

L1 cache cost (Icache $100) + (Dcache $100) = $200
L2 cache cost = $50; Memory cost = $75; Total cost = $325
Flushes = 17710  :  Invalidates = 17710
```

```
---------------------------------------------------------------
h264ref_L2_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 25818912066; Total refs = 10000000106
Flush time  = 459003736
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =       8490795943      [33.5%]
Writes  =       2543129242      [10.0%]
Inst.  =      14325983145      [56.5%]
Total  =      25359908330

Average cycles per activity:
Read = 3.2; Write = 4.4; Inst. = 3.8
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11160285566  Miss Count = 47791322
Total Requests = 11208076888
  Hit Rate = 99.6%  Miss Rate = 0.4%
Kickouts = 44719492; Dirty Kickouts = 0; Transfers = 47791322
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3940990857  Miss Count = 83744469
Total Requests = 4024735326
  Hit Rate = 97.9%  Miss Rate = 2.1%
Kickouts = 79223864; Dirty Kickouts = 20672723; Transfers = 85239755
Flush Kickouts = 1495286

Memory Level:  L2
Hit Count = 115073085  Miss Count = 38630715
Total Requests = 153703800
  Hit Rate = 74.9%  Miss Rate = 25.1%
Kickouts = 30281362; Dirty Kickouts = 5127126; Transfers = 41245301
Flush Kickouts = 2614586

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $150; Memory cost = $75; Total cost = $1025
Flushes = 17710  :  Invalidates = 17710
```

```
---------------------------------------------------------------
h264ref_L2_big.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 65536  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 26830734120; Total refs = 10000000106
Flush time  = 597280586
Inst refs  = 6730089151;  Data refs  = 3269910955

Number of reference types :  [Percentage]
Reads  =       2689845793      [26.9%]
Writes  =        580065162      [ 5.8%]
Inst.  =       6730089151     [67.3%]
Total  =      10000000106

Total cycles for activities:  [Percentage]
Reads  =       8949553517      [34.1%]
Writes  =       2778620409      [10.6%]
Inst.  =      14505279608      [55.3%]
Total  =      26233453534

Average cycles per activity:
Read = 3.3; Write = 4.8; Inst. = 3.9
Ideal: Exec. Time = 16730089257; CPI = 2.5
Ideal mis-aligned: Exec. Time = 21962901365; CPI = 3.3

Memory Level:  L1i
Hit Count = 11160285566  Miss Count = 47791322
Total Requests = 11208076888
  Hit Rate = 99.6%  Miss Rate = 0.4%
Kickouts = 44719492; Dirty Kickouts = 0; Transfers = 47791322
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3940990857  Miss Count = 83744469
Total Requests = 4024735326
  Hit Rate = 97.9%  Miss Rate = 2.1%
Kickouts = 79223864; Dirty Kickouts = 20672723; Transfers = 85239755
Flush Kickouts = 1495286

Memory Level:  L2
Hit Count = 111378673  Miss Count = 42325127
Total Requests = 153703800
  Hit Rate = 72.5%  Miss Rate = 27.5%
Kickouts = 30301962; Dirty Kickouts = 5995972; Transfers = 45674482
Flush Kickouts = 3349355

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 17710  :  Invalidates = 17710
```

```
---------------------------------------------------------------
libquantum_All_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 2  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 107260681086; Total refs = 16506492546
Flush time  = 1267133248
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      86764716181      [81.9%]
Writes  =       1197968976      [ 1.1%]
Inst.  =      18030862681      [17.0%]
Total  =     105993547838

Average cycles per activity:
Read = 24.6; Write = 2.4; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543263  Miss Count = 845790
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 4867; Dirty Kickouts = 0; Transfers = 845790
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262666441  Miss Count = 576950556
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568537628; Dirty Kickouts = 234411130; Transfers = 580300116
Flush Kickouts = 3349560

Memory Level:  L2
Hit Count = 526028650  Miss Count = 289528386
Total Requests = 815557036
  Hit Rate = 64.5%  Miss Rate = 35.5%
Kickouts = 272742878; Dirty Kickouts = 125971718; Transfers = 297120102
Flush Kickouts = 7591716

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_All_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 4  :  block size = 32
Icache size = 8192  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 107248844892; Total refs = 16506492546
Flush time  = 1266900142
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      86756713433      [81.9%]
Writes  =       1196009137      [ 1.1%]
Inst.  =      18029222180      [17.0%]
Total  =     105981944750

Average cycles per activity:
Read = 24.6; Write = 2.4; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543782  Miss Count = 845271
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2622; Dirty Kickouts = 0; Transfers = 845271
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262710581  Miss Count = 576906416
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568493488; Dirty Kickouts = 234391405; Transfers = 580255616
Flush Kickouts = 3349200

Memory Level:  L2
Hit Count = 526012853  Miss Count = 289479439
Total Requests = 815492292
  Hit Rate = 64.5%  Miss Rate = 35.5%
Kickouts = 272693097; Dirty Kickouts = 125957693; Transfers = 297070098
Flush Kickouts = 7590659

L1 cache cost (Icache $600) + (Dcache $600) = $1200
L2 cache cost = $150; Memory cost = $75; Total cost = $1425
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_All_FA_L2big.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 65536  :  ways = 1024  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 108415187548; Total refs = 16506492546
Flush time  = 2443740677
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      85584741291      [80.8%]
Writes  =       1183802981      [ 1.1%]
Inst.  =      19202902599      [18.1%]
Total  =     105971446871

Average cycles per activity:
Read = 24.3; Write = 2.4; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543918  Miss Count = 845135
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2003; Dirty Kickouts = 0; Transfers = 845135
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262710634  Miss Count = 576906363
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568493435; Dirty Kickouts = 234391076; Transfers = 580255703
Flush Kickouts = 3349340

Memory Level:  L2
Hit Count = 526064775  Miss Count = 289427139
Total Requests = 815491914
  Hit Rate = 64.5%  Miss Rate = 35.5%
Kickouts = 256463250; Dirty Kickouts = 118578619; Transfers = 304385885
Flush Kickouts = 14958746

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $1100; Memory cost = $75; Total cost = $4775
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_All_FA.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 32768  :  ways = 512  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 107286517495; Total refs = 16506492546
Flush time  = 1305545541
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      86716884160      [81.8%]
Writes  =       1196199205      [ 1.1%]
Inst.  =      18067888589      [17.0%]
Total  =     105980971954

Average cycles per activity:
Read = 24.6; Write = 2.4; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543918  Miss Count = 845135
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2003; Dirty Kickouts = 0; Transfers = 845135
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262710634  Miss Count = 576906363
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568493435; Dirty Kickouts = 234391076; Transfers = 580255703
Flush Kickouts = 3349340

Memory Level:  L2
Hit Count = 526017146  Miss Count = 289474768
Total Requests = 815491914
  Hit Rate = 64.5%  Miss Rate = 35.5%
Kickouts = 272684960; Dirty Kickouts = 125714276; Transfers = 297307676
Flush Kickouts = 7832908

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $500; Memory cost = $75; Total cost = $4175
Flushes = 32862  :  Invalidates = 32862
```

```
------------------------------------------------------------------
libquantum_defaults.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 108249525187; Total refs = 16506492546
Flush time  = 1253713938
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      87652198593      [81.9%]
Writes  =       1342072202      [ 1.3%]
Inst.  =      18001540454      [16.8%]
Total  =     106995811249

Average cycles per activity:
Read = 24.9; Write = 2.7; Inst. = 8.6
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620542016  Miss Count = 847037
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 8019; Dirty Kickouts = 0; Transfers = 847037
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6253479206  Miss Count = 586137791
Total Requests = 6839616997
  Hit Rate = 91.4%  Miss Rate = 8.6%
Kickouts = 577724863; Dirty Kickouts = 236116182; Transfers = 589493802
Flush Kickouts = 3356011

Memory Level:  L2
Hit Count = 533053853  Miss Count = 293403168
Total Requests = 826457021
  Hit Rate = 64.5%  Miss Rate = 35.5%
Kickouts = 276756337; Dirty Kickouts = 127193832; Transfers = 300913311
Flush Kickouts = 7510143

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $75; Total cost = $525
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_L1_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 107410179423; Total refs = 16506492546
Flush time  = 1271390419
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      86876076402      [81.9%]
Writes  =       1243516735      [ 1.2%]
Inst.  =      18019195867      [17.0%]
Total  =     106138789004

Average cycles per activity:
Read = 24.6; Write = 2.5; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543263  Miss Count = 845790
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 4867; Dirty Kickouts = 0; Transfers = 845790
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262666441  Miss Count = 576950556
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568537628; Dirty Kickouts = 234411130; Transfers = 580300116
Flush Kickouts = 3349560

Memory Level:  L2
Hit Count = 525264552  Miss Count = 290292484
Total Requests = 815557036
  Hit Rate = 64.4%  Miss Rate = 35.6%
Kickouts = 273645653; Dirty Kickouts = 126080485; Transfers = 297885663
Flush Kickouts = 7593179

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $50; Memory cost = $75; Total cost = $925
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_L1_8way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 8  :  block size = 32
Icache size = 8192  :  ways = 8  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 107391534447; Total refs = 16506492546
Flush time  = 1272068229
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      86878854466      [81.9%]
Writes  =       1220847119      [ 1.2%]
Inst.  =      18019764633      [17.0%]
Total  =     106119466218

Average cycles per activity:
Read = 24.6; Write = 2.5; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543923  Miss Count = 845130
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 2143; Dirty Kickouts = 0; Transfers = 845130
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262710638  Miss Count = 576906359
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568493431; Dirty Kickouts = 234390955; Transfers = 580255896
Flush Kickouts = 3349537

Memory Level:  L2
Hit Count = 525227569  Miss Count = 290264412
Total Requests = 815491981
  Hit Rate = 64.4%  Miss Rate = 35.6%
Kickouts = 273617581; Dirty Kickouts = 125995190; Transfers = 297857798
Flush Kickouts = 7593386

L1 cache cost (Icache $800) + (Dcache $800) = $1600
L2 cache cost = $50; Memory cost = $75; Total cost = $1725
Flushes = 32862  :  Invalidates = 32862
```

```
------------------------------------------------------------------
libquantum_L1_small_4way.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 4  :  block size = 32
Icache size = 4096  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 107307940416; Total refs = 16506492546
Flush time  = 1243102971
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      86829370336      [81.9%]
Writes  =       1232275937      [ 1.2%]
Inst.  =      18003191172      [17.0%]
Total  =     106064837445

Average cycles per activity:
Read = 24.6; Write = 2.5; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620542752  Miss Count = 846301
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 6062; Dirty Kickouts = 0; Transfers = 846301
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262691983  Miss Count = 576925014
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 572718550; Dirty Kickouts = 236079319; Transfers = 578587544
Flush Kickouts = 1662530

Memory Level:  L2
Hit Count = 525554024  Miss Count = 289959140
Total Requests = 815513164
  Hit Rate = 64.4%  Miss Rate = 35.6%
Kickouts = 273312309; Dirty Kickouts = 125975811; Transfers = 297546993
Flush Kickouts = 7587853

L1 cache cost (Icache $300) + (Dcache $300) = $600
L2 cache cost = $50; Memory cost = $75; Total cost = $725
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_L1_small.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 1  :  block size = 32
Icache size = 4096  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 108285033462; Total refs = 16506492546
Flush time  = 1226155310
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      87735760857      [82.0%]
Writes  =       1335196035      [ 1.2%]
Inst.  =      17987921260      [16.8%]
Total  =     107058878152

Average cycles per activity:
Read = 24.9; Write = 2.7; Inst. = 8.6
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620528007  Miss Count = 861046
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 69048; Dirty Kickouts = 0; Transfers = 861046
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6246272761  Miss Count = 593344236
Total Requests = 6839616997
  Hit Rate = 91.3%  Miss Rate = 8.7%
Kickouts = 589137772; Dirty Kickouts = 238794548; Transfers = 595009714
Flush Kickouts = 1665478

Memory Level:  L2
Hit Count = 541559868  Miss Count = 293105440
Total Requests = 834665308
  Hit Rate = 64.9%  Miss Rate = 35.1%
Kickouts = 276458609; Dirty Kickouts = 127091825; Transfers = 300607857
Flush Kickouts = 7502417

L1 cache cost (Icache $100) + (Dcache $100) = $200
L2 cache cost = $50; Memory cost = $75; Total cost = $325
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_L2_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 107249722874; Total refs = 16506492546
Flush time  = 1266637365
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      86757450906      [81.9%]
Writes  =       1196597459      [ 1.1%]
Inst.  =      18029037144      [17.0%]
Total  =     105983085509

Average cycles per activity:
Read = 24.6; Write = 2.4; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543263  Miss Count = 845790
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 4867; Dirty Kickouts = 0; Transfers = 845790
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262666441  Miss Count = 576950556
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568537628; Dirty Kickouts = 234411130; Transfers = 580300116
Flush Kickouts = 3349560

Memory Level:  L2
Hit Count = 526078217  Miss Count = 289478819
Total Requests = 815557036
  Hit Rate = 64.5%  Miss Rate = 35.5%
Kickouts = 272692477; Dirty Kickouts = 125959921; Transfers = 297068678
Flush Kickouts = 7589859

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $150; Memory cost = $75; Total cost = $1025
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
libquantum_L2_big.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 65536  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 108474926841; Total refs = 16506492546
Flush time  = 2409728003
Inst refs  = 12487578510;  Data refs  = 4018914036

Number of reference types :  [Percentage]
Reads  =       3526260463      [21.4%]
Writes  =        492653573      [ 3.0%]
Inst.  =      12487578510     [75.7%]
Total  =      16506492546

Total cycles for activities:  [Percentage]
Reads  =      85686604636      [80.8%]
Writes  =       1217720961      [ 1.1%]
Inst.  =      19160873241      [18.1%]
Total  =     106065198838

Average cycles per activity:
Read = 24.3; Write = 2.5; Inst. = 8.5
Ideal: Exec. Time = 28994071056; CPI = 2.3
Ideal mis-aligned: Exec. Time = 35948584560; CPI = 2.9

Memory Level:  L1i
Hit Count = 16620543263  Miss Count = 845790
Total Requests = 16621389053
  Hit Rate = 100.0%  Miss Rate = 0.0%
Kickouts = 4867; Dirty Kickouts = 0; Transfers = 845790
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 6262666441  Miss Count = 576950556
Total Requests = 6839616997
  Hit Rate = 91.6%  Miss Rate = 8.4%
Kickouts = 568537628; Dirty Kickouts = 234411130; Transfers = 580300116
Flush Kickouts = 3349560

Memory Level:  L2
Hit Count = 525604450  Miss Count = 289952586
Total Requests = 815557036
  Hit Rate = 64.4%  Miss Rate = 35.6%
Kickouts = 257143312; Dirty Kickouts = 118855650; Transfers = 304665430
Flush Kickouts = 14712844

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 32862  :  Invalidates = 32862
```

```
---------------------------------------------------------------
omnetpp_All_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 2  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 82029355234; Total refs = 10000000076
Flush time  = 655632485
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      36766994360      [45.2%]
Writes  =       8301079521      [10.2%]
Inst.  =      36305648868      [44.6%]
Total  =      81373722749

Average cycles per activity:
Read = 18.3; Write = 6.7; Inst. = 12.1
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11118333347  Miss Count = 341151726
Total Requests = 11459485073
  Hit Rate = 97.0%  Miss Rate = 3.0%
Kickouts = 336631094; Dirty Kickouts = 0; Transfers = 341151726
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5675568402  Miss Count = 262045382
Total Requests = 5937613784
  Hit Rate = 95.6%  Miss Rate = 4.4%
Kickouts = 257498822; Dirty Kickouts = 104790863; Transfers = 264066286
Flush Kickouts = 2020904

Memory Level:  L2
Hit Count = 453912478  Miss Count = 256096397
Total Requests = 710008875
  Hit Rate = 63.9%  Miss Rate = 36.1%
Kickouts = 247005837; Dirty Kickouts = 58840909; Transfers = 259475459
Flush Kickouts = 3379062

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_All_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 4  :  block size = 32
Icache size = 8192  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 70284146604; Total refs = 10000000076
Flush time  = 646342310
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      31988071793      [45.9%]
Writes  =       7499972380      [10.8%]
Inst.  =      30149760121      [43.3%]
Total  =      69637804294

Average cycles per activity:
Read = 15.9; Write = 6.1; Inst. = 10.3
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11172241478  Miss Count = 287243595
Total Requests = 11459485073
  Hit Rate = 97.5%  Miss Rate = 2.5%
Kickouts = 282697388; Dirty Kickouts = 0; Transfers = 287243595
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5716738958  Miss Count = 220874826
Total Requests = 5937613784
  Hit Rate = 96.3%  Miss Rate = 3.7%
Kickouts = 216328266; Dirty Kickouts = 84698427; Transfers = 222939467
Flush Kickouts = 2064641

Memory Level:  L2
Hit Count = 388758306  Miss Count = 206123183
Total Requests = 594881489
  Hit Rate = 65.4%  Miss Rate = 34.6%
Kickouts = 197030083; Dirty Kickouts = 49081480; Transfers = 209459160
Flush Kickouts = 3335977

L1 cache cost (Icache $600) + (Dcache $600) = $1200
L2 cache cost = $150; Memory cost = $75; Total cost = $1425
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_All_FA_L2big.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 65536  :  ways = 1024  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 48032604706; Total refs = 10000000076
Flush time  = 1089925936
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      21244617150      [45.3%]
Writes  =       5910130216      [12.6%]
Inst.  =      19787931404      [42.2%]
Total  =      46942678770

Average cycles per activity:
Read = 10.6; Write = 4.8; Inst. = 7.0
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11255563338  Miss Count = 203921735
Total Requests = 11459485073
  Hit Rate = 98.2%  Miss Rate = 1.8%
Kickouts = 199375350; Dirty Kickouts = 0; Transfers = 203921735
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5758964173  Miss Count = 178649611
Total Requests = 5937613784
  Hit Rate = 97.0%  Miss Rate = 3.0%
Kickouts = 174103051; Dirty Kickouts = 71366416; Transfers = 180733918
Flush Kickouts = 2084307

Memory Level:  L2
Hit Count = 354074673  Miss Count = 101947396
Total Requests = 456022069
  Hit Rate = 77.6%  Miss Rate = 22.4%
Kickouts = 83761156; Dirty Kickouts = 26698115; Transfers = 108358421
Flush Kickouts = 6411025

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $1100; Memory cost = $75; Total cost = $4775
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_All_FA.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 32768  :  ways = 512  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 60620863018; Total refs = 10000000076
Flush time  = 636552437
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      27380847345      [45.6%]
Writes  =       6955833533      [11.6%]
Inst.  =      25647629703      [42.8%]
Total  =      59984310581

Average cycles per activity:
Read = 13.6; Write = 5.6; Inst. = 8.9
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11255563338  Miss Count = 203921735
Total Requests = 11459485073
  Hit Rate = 98.2%  Miss Rate = 1.8%
Kickouts = 199375350; Dirty Kickouts = 0; Transfers = 203921735
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5758964173  Miss Count = 178649611
Total Requests = 5937613784
  Hit Rate = 97.0%  Miss Rate = 3.0%
Kickouts = 174103051; Dirty Kickouts = 71366416; Transfers = 180733918
Flush Kickouts = 2084307

Memory Level:  L2
Hit Count = 288309260  Miss Count = 167712809
Total Requests = 456022069
  Hit Rate = 63.2%  Miss Rate = 36.8%
Kickouts = 158619689; Dirty Kickouts = 42646895; Transfers = 171042603
Flush Kickouts = 3329794

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $500; Memory cost = $75; Total cost = $4175
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_defaults.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 105194177165; Total refs = 10000000076
Flush time  = 655736294
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      48347587579      [46.2%]
Writes  =      10805872313      [10.3%]
Inst.  =      45384980979      [43.4%]
Total  =     104538440871

Average cycles per activity:
Read = 24.0; Write = 8.7; Inst. = 15.5
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11001025667  Miss Count = 458459406
Total Requests = 11459485073
  Hit Rate = 96.0%  Miss Rate = 4.0%
Kickouts = 454141835; Dirty Kickouts = 0; Transfers = 458459406
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5568475800  Miss Count = 369137984
Total Requests = 5937613784
  Hit Rate = 93.8%  Miss Rate = 6.2%
Kickouts = 364591485; Dirty Kickouts = 161396759; Transfers = 371088233
Flush Kickouts = 1950249

Memory Level:  L2
Hit Count = 644430396  Miss Count = 346514002
Total Requests = 990944398
  Hit Rate = 65.0%  Miss Rate = 35.0%
Kickouts = 337480071; Dirty Kickouts = 81547200; Transfers = 349852679
Flush Kickouts = 3338677

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $75; Total cost = $525
Flushes = 17759  :  Invalidates = 17759
```

```
------------------------------------------------------------------
omnetpp_L1_2way.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 89465410677; Total refs = 10000000076
Flush time  = 694960668
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      40359663239      [45.5%]
Writes  =       9005917721      [10.1%]
Inst.  =      39404869049      [44.4%]
Total  =      88770450009

Average cycles per activity:
Read = 20.1; Write = 7.3; Inst. = 13.2
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11118333347  Miss Count = 341151726
Total Requests = 11459485073
  Hit Rate = 97.0%  Miss Rate = 3.0%
Kickouts = 336631094; Dirty Kickouts = 0; Transfers = 341151726
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5675568402  Miss Count = 262045382
Total Requests = 5937613784
  Hit Rate = 95.6%  Miss Rate = 4.4%
Kickouts = 257498822; Dirty Kickouts = 104790863; Transfers = 264066286
Flush Kickouts = 2020904

Memory Level:  L2
Hit Count = 415208698  Miss Count = 294800177
Total Requests = 710008875
  Hit Rate = 58.5%  Miss Rate = 41.5%
Kickouts = 285766246; Dirty Kickouts = 64668964; Transfers = 298183659
Flush Kickouts = 3383482

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $50; Memory cost = $75; Total cost = $925
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_L1_8way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 8  :  block size = 32
Icache size = 8192  :  ways = 8  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 75995164217; Total refs = 10000000076
Flush time  = 737176423
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      33335550580      [44.3%]
Writes  =       8004600769      [10.6%]
Inst.  =      33917836445      [45.1%]
Total  =      75257987794

Average cycles per activity:
Read = 16.6; Write = 6.5; Inst. = 11.2
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11196786235  Miss Count = 262698838
Total Requests = 11459485073
  Hit Rate = 97.7%  Miss Rate = 2.3%
Kickouts = 258152461; Dirty Kickouts = 0; Transfers = 262698838
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5740720184  Miss Count = 196893600
Total Requests = 5937613784
  Hit Rate = 96.7%  Miss Rate = 3.3%
Kickouts = 192347040; Dirty Kickouts = 76592811; Transfers = 198969396
Flush Kickouts = 2075796

Memory Level:  L2
Hit Count = 295795213  Miss Count = 242465832
Total Requests = 538261045
  Hit Rate = 55.0%  Miss Rate = 45.0%
Kickouts = 233431901; Dirty Kickouts = 51782322; Transfers = 245905928
Flush Kickouts = 3440096

L1 cache cost (Icache $800) + (Dcache $800) = $1600
L2 cache cost = $50; Memory cost = $75; Total cost = $1725
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_L1_small_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 4  :  block size = 32
Icache size = 4096  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 112567218800; Total refs = 10000000076
Flush time  = 522660286
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      47375952557      [42.3%]
Writes  =       9481535713      [ 8.5%]
Inst.  =      55187070244      [49.3%]
Total  =     112044558514

Average cycles per activity:
Read = 23.5; Write = 7.7; Inst. = 16.6
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 10797463020  Miss Count = 662022053
Total Requests = 11459485073
  Hit Rate = 94.2%  Miss Rate = 5.8%
Kickouts = 659748821; Dirty Kickouts = 0; Transfers = 662022053
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5577120317  Miss Count = 360493467
Total Requests = 5937613784
  Hit Rate = 93.9%  Miss Rate = 6.1%
Kickouts = 358220187; Dirty Kickouts = 138937083; Transfers = 361558962
Flush Kickouts = 1065495

Memory Level:  L2
Hit Count = 780952197  Miss Count = 381565901
Total Requests = 1162518098
  Hit Rate = 67.2%  Miss Rate = 32.8%
Kickouts = 372531970; Dirty Kickouts = 75051309; Transfers = 384425012
Flush Kickouts = 2859111

L1 cache cost (Icache $300) + (Dcache $300) = $600
L2 cache cost = $50; Memory cost = $75; Total cost = $725
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_L1_small.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 1  :  block size = 32
Icache size = 4096  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 122631067982; Total refs = 10000000076
Flush time  = 502378329
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      54503976423      [44.6%]
Writes  =      11412022335      [ 9.3%]
Inst.  =      56212690895      [46.0%]
Total  =     122128689653

Average cycles per activity:
Read = 27.1; Write = 9.2; Inst. = 18.1
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 10787606038  Miss Count = 671879035
Total Requests = 11459485073
  Hit Rate = 94.1%  Miss Rate = 5.9%
Kickouts = 669605955; Dirty Kickouts = 0; Transfers = 671879035
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5431113100  Miss Count = 506500684
Total Requests = 5937613784
  Hit Rate = 91.5%  Miss Rate = 8.5%
Kickouts = 504227404; Dirty Kickouts = 216081736; Transfers = 507492305
Flush Kickouts = 991621

Memory Level:  L2
Hit Count = 989572725  Miss Count = 405880351
Total Requests = 1395453076
  Hit Rate = 70.9%  Miss Rate = 29.1%
Kickouts = 396846420; Dirty Kickouts = 89897303; Transfers = 408729275
Flush Kickouts = 2848924

L1 cache cost (Icache $100) + (Dcache $100) = $200
L2 cache cost = $50; Memory cost = $75; Total cost = $325
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_L2_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 75131696835; Total refs = 10000000076
Flush time  = 617972500
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      33604571151      [45.1%]
Writes  =       7889046837      [10.6%]
Inst.  =      33020106347      [44.3%]
Total  =      74513724335

Average cycles per activity:
Read = 16.7; Write = 6.4; Inst. = 11.0
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11118333347  Miss Count = 341151726
Total Requests = 11459485073
  Hit Rate = 97.0%  Miss Rate = 3.0%
Kickouts = 336631094; Dirty Kickouts = 0; Transfers = 341151726
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5675568402  Miss Count = 262045382
Total Requests = 5937613784
  Hit Rate = 95.6%  Miss Rate = 4.4%
Kickouts = 257498822; Dirty Kickouts = 104790863; Transfers = 264066286
Flush Kickouts = 2020904

Memory Level:  L2
Hit Count = 488961280  Miss Count = 221047595
Total Requests = 710008875
  Hit Rate = 68.9%  Miss Rate = 31.1%
Kickouts = 211954495; Dirty Kickouts = 52634505; Transfers = 224340258
Flush Kickouts = 3292663

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $150; Memory cost = $75; Total cost = $1025
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
omnetpp_L2_big.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 65536  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 72913835611; Total refs = 10000000076
Flush time  = 1040646632
Inst refs  = 6748671723;  Data refs  = 3251328353

Number of reference types :  [Percentage]
Reads  =       2011922989      [20.1%]
Writes  =       1239405364      [12.4%]
Inst.  =       6748671723     [67.5%]
Total  =      10000000076

Total cycles for activities:  [Percentage]
Reads  =      32030086301      [44.6%]
Writes  =       7484736031      [10.4%]
Inst.  =      32358366647      [45.0%]
Total  =      71873188979

Average cycles per activity:
Read = 15.9; Write = 6.0; Inst. = 10.6
Ideal: Exec. Time = 16748671799; CPI = 2.5
Ideal mis-aligned: Exec. Time = 24145770580; CPI = 3.6

Memory Level:  L1i
Hit Count = 11118333347  Miss Count = 341151726
Total Requests = 11459485073
  Hit Rate = 97.0%  Miss Rate = 3.0%
Kickouts = 336631094; Dirty Kickouts = 0; Transfers = 341151726
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 5675568402  Miss Count = 262045382
Total Requests = 5937613784
  Hit Rate = 95.6%  Miss Rate = 4.4%
Kickouts = 257498822; Dirty Kickouts = 104790863; Transfers = 264066286
Flush Kickouts = 2020904

Memory Level:  L2
Hit Count = 502326148  Miss Count = 207682727
Total Requests = 710008875
  Hit Rate = 70.7%  Miss Rate = 29.3%
Kickouts = 191072558; Dirty Kickouts = 47529666; Transfers = 213526464
Flush Kickouts = 5843737

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 17759  :  Invalidates = 17759
```

```
---------------------------------------------------------------
sjeng_All_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 2  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 44300992452; Total refs = 10000000109
Flush time  = 589120731
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =      10477993739      [24.0%]
Writes  =       7023616800      [16.1%]
Inst.  =      26210261182      [60.0%]
Total  =      43711871721

Average cycles per activity:
Read = 5.5; Write = 9.7; Inst. = 5.9
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12329298530  Miss Count = 223077262
Total Requests = 12552375792
  Hit Rate = 98.2%  Miss Rate = 1.8%
Kickouts = 218150210; Dirty Kickouts = 0; Transfers = 223077262
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3176318967  Miss Count = 121259542
Total Requests = 3297578509
  Hit Rate = 96.3%  Miss Rate = 3.7%
Kickouts = 116336783; Dirty Kickouts = 53348235; Transfers = 123513368
Flush Kickouts = 2253826

Memory Level:  L2
Hit Count = 296066562  Miss Count = 103872303
Total Requests = 399938865
  Hit Rate = 74.0%  Miss Rate = 26.0%
Kickouts = 94428215; Dirty Kickouts = 23349102; Transfers = 106597095
Flush Kickouts = 2724792

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_All_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 4  :  block size = 32
Icache size = 8192  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 40380511353; Total refs = 10000000109
Flush time  = 614653974
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       9539682524      [24.0%]
Writes  =       6034448117      [15.2%]
Inst.  =      24191726738      [60.8%]
Total  =      39765857379

Average cycles per activity:
Read = 5.0; Write = 8.3; Inst. = 5.4
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12332868797  Miss Count = 219506995
Total Requests = 12552375792
  Hit Rate = 98.3%  Miss Rate = 1.7%
Kickouts = 214571765; Dirty Kickouts = 0; Transfers = 219506995
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3200939266  Miss Count = 96639243
Total Requests = 3297578509
  Hit Rate = 97.1%  Miss Rate = 2.9%
Kickouts = 91680120; Dirty Kickouts = 43578332; Transfers = 99075132
Flush Kickouts = 2435889

Memory Level:  L2
Hit Count = 275258214  Miss Count = 86902245
Total Requests = 362160459
  Hit Rate = 76.0%  Miss Rate = 24.0%
Kickouts = 77135113; Dirty Kickouts = 20032092; Transfers = 89711872
Flush Kickouts = 2809627

L1 cache cost (Icache $600) + (Dcache $600) = $1200
L2 cache cost = $150; Memory cost = $75; Total cost = $1425
Flushes = 19380  :  Invalidates = 19380
```

```
-----------------------------------------------------------------
sjeng_All_FA_L2big.dat Simulation Results
-----------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 65536  :  ways = 1024  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 28934606676; Total refs = 10000000109
Flush time  = 1037611846
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       4596772368      [16.5%]
Writes  =       4473806936      [16.0%]
Inst.  =      18826415526      [67.5%]
Total  =      27896994830

Average cycles per activity:
Read = 2.4; Write = 6.1; Inst. = 3.8
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12304531662  Miss Count = 247844130
Total Requests = 12552375792
  Hit Rate = 98.0%  Miss Rate = 2.0%
Kickouts = 242908780; Dirty Kickouts = 0; Transfers = 247844130
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3228649349  Miss Count = 68929160
Total Requests = 3297578509
  Hit Rate = 97.9%  Miss Rate = 2.1%
Kickouts = 63967624; Dirty Kickouts = 35733591; Transfers = 71351092
Flush Kickouts = 2421932

Memory Level:  L2
Hit Count = 328808401  Miss Count = 26120412
Total Requests = 354928813
  Hit Rate = 92.6%  Miss Rate = 7.4%
Kickouts = 7149949; Dirty Kickouts = 6688904; Transfers = 32207922
Flush Kickouts = 6087510

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $1100; Memory cost = $75; Total cost = $4775
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_All_FA.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 256  :  block size = 32
Icache size = 8192  :  ways = 256  :  block size = 32
L2-cache size = 32768  :  ways = 512  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 33993861102; Total refs = 10000000109
Flush time  = 585150723
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       7141935346      [21.4%]
Writes  =       5112141054      [15.3%]
Inst.  =      21154633979      [63.3%]
Total  =      33408710379

Average cycles per activity:
Read = 3.7; Write = 7.0; Inst. = 4.5
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12304531662  Miss Count = 247844130
Total Requests = 12552375792
  Hit Rate = 98.0%  Miss Rate = 2.0%
Kickouts = 242908780; Dirty Kickouts = 0; Transfers = 247844130
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3228649349  Miss Count = 68929160
Total Requests = 3297578509
  Hit Rate = 97.9%  Miss Rate = 2.1%
Kickouts = 63967624; Dirty Kickouts = 35733591; Transfers = 71351092
Flush Kickouts = 2421932

Memory Level:  L2
Hit Count = 299602134  Miss Count = 55326679
Total Requests = 354928813
  Hit Rate = 84.4%  Miss Rate = 15.6%
Kickouts = 45403966; Dirty Kickouts = 14057453; Transfers = 58009821
Flush Kickouts = 2683142

L1 cache cost (Icache $1800) + (Dcache $1800) = $3600
L2 cache cost = $500; Memory cost = $75; Total cost = $4175
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_defaults.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 53574291155; Total refs = 10000000109
Flush time  = 578295505
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =      15529463104      [29.3%]
Writes  =       7799108595      [14.7%]
Inst.  =      29667423951      [56.0%]
Total  =      52995995650

Average cycles per activity:
Read = 8.1; Write = 10.7; Inst. = 7.2
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12315460748  Miss Count = 236915044
Total Requests = 12552375792
  Hit Rate = 98.1%  Miss Rate = 1.9%
Kickouts = 232095465; Dirty Kickouts = 0; Transfers = 236915044
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3108702506  Miss Count = 188876003
Total Requests = 3297578509
  Hit Rate = 94.3%  Miss Rate = 5.7%
Kickouts = 184181921; Dirty Kickouts = 74706271; Transfers = 190939943
Flush Kickouts = 2063940

Memory Level:  L2
Hit Count = 358958322  Miss Count = 143602936
Total Requests = 502561258
  Hit Rate = 71.4%  Miss Rate = 28.6%
Kickouts = 134852805; Dirty Kickouts = 29789810; Transfers = 146314008
Flush Kickouts = 2711072

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $75; Total cost = $525
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_L1_2way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 48127101144; Total refs = 10000000109
Flush time  = 610698621
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =      12212215828      [25.7%]
Writes  =       7301114606      [15.4%]
Inst.  =      28003072089      [58.9%]
Total  =      47516402523

Average cycles per activity:
Read = 6.4; Write = 10.0; Inst. = 6.5
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12329298530  Miss Count = 223077262
Total Requests = 12552375792
  Hit Rate = 98.2%  Miss Rate = 1.8%
Kickouts = 218150210; Dirty Kickouts = 0; Transfers = 223077262
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3176318967  Miss Count = 121259542
Total Requests = 3297578509
  Hit Rate = 96.3%  Miss Rate = 3.7%
Kickouts = 116336783; Dirty Kickouts = 53348235; Transfers = 123513368
Flush Kickouts = 2253826

Memory Level:  L2
Hit Count = 275423716  Miss Count = 124515149
Total Requests = 399938865
  Hit Rate = 68.9%  Miss Rate = 31.1%
Kickouts = 115765018; Dirty Kickouts = 25558238; Transfers = 127263152
Flush Kickouts = 2748003

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $50; Memory cost = $75; Total cost = $925
Flushes = 19380  :  Invalidates = 19380
```

```
-------------------------------------------------------------------
sjeng_L1_8way.dat Simulation Results
-------------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 8  :  block size = 32
Icache size = 8192  :  ways = 8  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 44244084878; Total refs = 10000000109
Flush time  = 677307406
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       9991306839      [22.9%]
Writes  =       6342049093      [14.6%]
Inst.  =      27233421540      [62.5%]
Total  =      43566777472

Average cycles per activity:
Read = 5.2; Write = 8.7; Inst. = 5.9
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12325674941  Miss Count = 226700851
Total Requests = 12552375792
  Hit Rate = 98.2%  Miss Rate = 1.8%
Kickouts = 221765528; Dirty Kickouts = 0; Transfers = 226700851
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3215035005  Miss Count = 82543504
Total Requests = 3297578509
  Hit Rate = 97.5%  Miss Rate = 2.5%
Kickouts = 77582058; Dirty Kickouts = 38144847; Transfers = 85027259
Flush Kickouts = 2483755

Memory Level:  L2
Hit Count = 239721074  Miss Count = 110151883
Total Requests = 349872957
  Hit Rate = 68.5%  Miss Rate = 31.5%
Kickouts = 101401752; Dirty Kickouts = 20836291; Transfers = 112841342
Flush Kickouts = 2689459

L1 cache cost (Icache $800) + (Dcache $800) = $1600
L2 cache cost = $50; Memory cost = $75; Total cost = $1725
Flushes = 19380  :  Invalidates = 19380
```

```
------------------------------------------------------------------
sjeng_L1_small_4way.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 4  :  block size = 32
Icache size = 4096  :  ways = 4  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 58053201587; Total refs = 10000000109
Flush time  = 435058746
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =      16588370442      [28.8%]
Writes  =       7373847033      [12.8%]
Inst.  =      33655925366      [58.4%]
Total  =      57618142841

Average cycles per activity:
Read = 8.7; Write = 10.1; Inst. = 7.8
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12210515336  Miss Count = 341860456
Total Requests = 12552375792
  Hit Rate = 97.3%  Miss Rate = 2.7%
Kickouts = 339392562; Dirty Kickouts = 0; Transfers = 341860456
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3121957304  Miss Count = 175621205
Total Requests = 3297578509
  Hit Rate = 94.7%  Miss Rate = 5.3%
Kickouts = 173140439; Dirty Kickouts = 69680495; Transfers = 176771792
Flush Kickouts = 1150587

Memory Level:  L2
Hit Count = 425937741  Miss Count = 162375002
Total Requests = 588312743
  Hit Rate = 72.4%  Miss Rate = 27.6%
Kickouts = 153624871; Dirty Kickouts = 30855502; Transfers = 164703190
Flush Kickouts = 2328188

L1 cache cost (Icache $300) + (Dcache $300) = $600
L2 cache cost = $50; Memory cost = $75; Total cost = $725
Flushes = 19380  :  Invalidates = 19380
```

```
------------------------------------------------------------------
sjeng_L1_small.dat Simulation Results
------------------------------------------------------------------

Memory System:
Dcache size = 4096  :  ways = 1  :  block size = 32
Icache size = 4096  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 64377904161; Total refs = 10000000109
Flush time  = 417902704
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =      20529757060      [32.1%]
Writes  =       8411003730      [13.2%]
Inst.  =      35019240667      [54.8%]
Total  =      63960001457

Average cycles per activity:
Read = 10.8; Write = 11.6; Inst. = 8.7
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12184655643  Miss Count = 367720149
Total Requests = 12552375792
  Hit Rate = 97.1%  Miss Rate = 2.9%
Kickouts = 365252531; Dirty Kickouts = 0; Transfers = 367720149
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 2973403604  Miss Count = 324174905
Total Requests = 3297578509
  Hit Rate = 90.2%  Miss Rate = 9.8%
Kickouts = 321698344; Dirty Kickouts = 121570257; Transfers = 325178148
Flush Kickouts = 1003243

Memory Level:  L2
Hit Count = 639175258  Miss Count = 175293296
Total Requests = 814468554
  Hit Rate = 78.5%  Miss Rate = 21.5%
Kickouts = 166543165; Dirty Kickouts = 34738606; Transfers = 177599336
Flush Kickouts = 2306040

L1 cache cost (Icache $100) + (Dcache $100) = $200
L2 cache cost = $50; Memory cost = $75; Total cost = $325
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_L2_4way.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 32768  :  ways = 4  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 41225407974; Total refs = 10000000109
Flush time  = 583231991
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       9790459257      [24.1%]
Writes  =       6315919825      [15.5%]
Inst.  =      24535796901      [60.4%]
Total  =      40642175983

Average cycles per activity:
Read = 5.1; Write = 8.7; Inst. = 5.5
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12329298530  Miss Count = 223077262
Total Requests = 12552375792
  Hit Rate = 98.2%  Miss Rate = 1.8%
Kickouts = 218150210; Dirty Kickouts = 0; Transfers = 223077262
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3176318967  Miss Count = 121259542
Total Requests = 3297578509
  Hit Rate = 96.3%  Miss Rate = 3.7%
Kickouts = 116336783; Dirty Kickouts = 53348235; Transfers = 123513368
Flush Kickouts = 2253826

Memory Level:  L2
Hit Count = 311873176  Miss Count = 88065689
Total Requests = 399938865
  Hit Rate = 78.0%  Miss Rate = 22.0%
Kickouts = 78298557; Dirty Kickouts = 20596921; Transfers = 90855217
Flush Kickouts = 2789528

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $150; Memory cost = $75; Total cost = $1025
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_L2_big.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 2  :  block size = 32
Icache size = 8192  :  ways = 2  :  block size = 32
L2-cache size = 65536  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 8  :  chunktime = 15

Execute time  = 39156215813; Total refs = 10000000109
Flush time  = 763543437
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       9162625352      [23.9%]
Writes  =       5899887603      [15.4%]
Inst.  =      23330159421      [60.8%]
Total  =      38392672376

Average cycles per activity:
Read = 4.8; Write = 8.1; Inst. = 5.2
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12329298530  Miss Count = 223077262
Total Requests = 12552375792
  Hit Rate = 98.2%  Miss Rate = 1.8%
Kickouts = 218150210; Dirty Kickouts = 0; Transfers = 223077262
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3176318967  Miss Count = 121259542
Total Requests = 3297578509
  Hit Rate = 96.3%  Miss Rate = 3.7%
Kickouts = 116336783; Dirty Kickouts = 53348235; Transfers = 123513368
Flush Kickouts = 2253826

Memory Level:  L2
Hit Count = 322584777  Miss Count = 77354088
Total Requests = 399938865
  Hit Rate = 80.7%  Miss Rate = 19.3%
Kickouts = 64451997; Dirty Kickouts = 16389256; Transfers = 81472117
Flush Kickouts = 4118029

L1 cache cost (Icache $400) + (Dcache $400) = $800
L2 cache cost = $100; Memory cost = $75; Total cost = $975
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_chunk16.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 16  :  chunktime = 15

Execute time  = 42804461615; Total refs = 10000000109
Flush time  = 374695045
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =      11763620944      [27.7%]
Writes  =       5802400395      [13.7%]
Inst.  =      24863745231      [58.6%]
Total  =      42429766570

Average cycles per activity:
Read = 6.2; Write = 8.0; Inst. = 5.8
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12315460748  Miss Count = 236915044
Total Requests = 12552375792
  Hit Rate = 98.1%  Miss Rate = 1.9%
Kickouts = 232095465; Dirty Kickouts = 0; Transfers = 236915044
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3108702506  Miss Count = 188876003
Total Requests = 3297578509
  Hit Rate = 94.3%  Miss Rate = 5.7%
Kickouts = 184181921; Dirty Kickouts = 74706271; Transfers = 190939943
Flush Kickouts = 2063940

Memory Level:  L2
Hit Count = 358958322  Miss Count = 143602936
Total Requests = 502561258
  Hit Rate = 71.4%  Miss Rate = 28.6%
Kickouts = 134852805; Dirty Kickouts = 29789810; Transfers = 146314008
Flush Kickouts = 2711072

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $175; Total cost = $625
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_chunk32.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 32  :  chunktime = 15

Execute time  = 37419546845; Total refs = 10000000109
Flush time  = 272894815
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       9880699864      [26.6%]
Writes  =       4804046295      [12.9%]
Inst.  =      22461905871      [60.5%]
Total  =      37146652030

Average cycles per activity:
Read = 5.2; Write = 6.6; Inst. = 5.0
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12315460748  Miss Count = 236915044
Total Requests = 12552375792
  Hit Rate = 98.1%  Miss Rate = 1.9%
Kickouts = 232095465; Dirty Kickouts = 0; Transfers = 236915044
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3108702506  Miss Count = 188876003
Total Requests = 3297578509
  Hit Rate = 94.3%  Miss Rate = 5.7%
Kickouts = 184181921; Dirty Kickouts = 74706271; Transfers = 190939943
Flush Kickouts = 2063940

Memory Level:  L2
Hit Count = 358958322  Miss Count = 143602936
Total Requests = 502561258
  Hit Rate = 71.4%  Miss Rate = 28.6%
Kickouts = 134852805; Dirty Kickouts = 29789810; Transfers = 146314008
Flush Kickouts = 2711072

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $275; Total cost = $725
Flushes = 19380  :  Invalidates = 19380
```

```
---------------------------------------------------------------
sjeng_chunk64.dat Simulation Results
---------------------------------------------------------------

Memory System:
Dcache size = 8192  :  ways = 1  :  block size = 32
Icache size = 8192  :  ways = 1  :  block size = 32
L2-cache size = 32768  :  ways = 1  :  block size = 64
Memory ready time = 30  :  chunksize = 64  :  chunktime = 15

Execute time  = 34727089460; Total refs = 10000000109
Flush time  = 221994700
Inst refs  = 7364538494;  Data refs  = 2635461615

Number of reference types :  [Percentage]
Reads  =       1907768017      [19.1%]
Writes  =        727693598      [ 7.3%]
Inst.  =       7364538494     [73.6%]
Total  =      10000000109

Total cycles for activities:  [Percentage]
Reads  =       8939239324      [25.9%]
Writes  =       4304869245      [12.5%]
Inst.  =      21260986191      [61.6%]
Total  =      34505094760

Average cycles per activity:
Read = 4.7; Write = 5.9; Inst. = 4.7
Ideal: Exec. Time = 17364538603; CPI = 2.4
Ideal mis-aligned: Exec. Time = 23214492795; CPI = 3.2

Memory Level:  L1i
Hit Count = 12315460748  Miss Count = 236915044
Total Requests = 12552375792
  Hit Rate = 98.1%  Miss Rate = 1.9%
Kickouts = 232095465; Dirty Kickouts = 0; Transfers = 236915044
Flush Kickouts = 0

Memory Level:  L1d
Hit Count = 3108702506  Miss Count = 188876003
Total Requests = 3297578509
  Hit Rate = 94.3%  Miss Rate = 5.7%
Kickouts = 184181921; Dirty Kickouts = 74706271; Transfers = 190939943
Flush Kickouts = 2063940

Memory Level:  L2
Hit Count = 358958322  Miss Count = 143602936
Total Requests = 502561258
  Hit Rate = 71.4%  Miss Rate = 28.6%
Kickouts = 134852805; Dirty Kickouts = 29789810; Transfers = 146314008
Flush Kickouts = 2711072

L1 cache cost (Icache $200) + (Dcache $200) = $400
L2 cache cost = $50; Memory cost = $375; Total cost = $825
Flushes = 19380  :  Invalidates = 19380
```