Lab3 报告

- 姓名：郑伟林
- 班级：1619303
- 学号：061920125
- 报告阶段：lab3
- 完成日期：2021.6.16
- 本次实验，我完成了所有内容。

目录

init_cache （20分）

- cache结构设计
  - 思路

    首先建立cache行`line`结构体，其包含有效位`valid_bit`，脏位`dirty_bit`，标记tag，`块`号`block_num`和块数组`block`。`line`用以表示cache中的一行。

    然后建立`CACHE`结构体，其包含`line`类型的二维指针`cache`，用以生成cache，还辅以两个参数：组数`grow_num`和路数`way_num`。

    最后定义一个`CACHE`类型的cache实例`c`。
  - 代码

```
typedef struct
{
    uint8_t block[BLOCK_SIZE]; //块
    bool valid_bit;            //有效位
    bool dirty_bit;            //脏位
    uint32_t tag;              //标记
    uint32_t block_num;        //块号
} line;

typedef struct
{
    line **cache;
    int grow_num;
    int way_num;
} CACHE;

CACHE c; //实例化一个cache
```

- cache初始化
  - 思路

    先计算组数`grow_num`和路数`way_num`，然后动态申请二维数组`cache`的空间，并将`cache`中所有字段初始化为0.
  - 代码

    ```
    // 初始化一个数据大小为`2^total_size_width`B，关联度为`2^associativity_width`的cache
    // 例如`init_cache(14, 2)`将初始化一个16KB，4路组相联的cache
    // 将所有valid bit置为无效即可
    void init_cache(int total_size_width, int associativity_width)
    {
        c.grow_num = (1 << total_size_width) / (BLOCK_SIZE * (1 << associativity_width));
        c.way_num = 1 << associativity_width;

        c.cache = (line **)malloc(c.grow_num * sizeof(line *));
        for (int i = 0; i < c.grow_num; i++)
            c.cache[i] = (line *)malloc(c.way_num * sizeof(line));

        for (int i = 0; i < c.grow_num; i++)
        {
            for (int j = 0; j < c.way_num; j++)
            {
                c.cache[i][j].valid_bit = 0;
                c.cache[i][j].dirty_bit = 0;
                c.cache[i][j].tag = 0;
                c.cache[i][j].block_num = 0;
                memset(c.cache[i][j].block, 0, sizeof(c.cache[i][j].block));
            }
        }
    }
    ```

cache_read (30分)

- 思路

  首先取得`addr`中的组号`num_of_grow`，然后遍历`cache`中该组，查询是否命中，若命中了，读取出数据。

  如果未命中，则先查询组是否已满，满了的话取组中随机一行，若脏位标记是1将其写回内存，再进行读取数据；如果未满，则直接读取数据，并更新`cache`行信息。
- 代码

  ```
  // 从cache中读出`addr`地址处的4字节数据
  // 若缺失，需要先从内存中读入数据
  uint32_t cache_read(uintptr_t addr)
  {
      int num_of_grow = (addr >> BLOCK_WIDTH) % c.grow_num; //取地址中的cache组号
      bool is_hit = false;
      uint32_t *p = NULL;
      int tag_offset = (BLOCK_WIDTH + (int)(log(c.grow_num) / log(2.0)));

      for (int i = 0; i < c.way_num; i++)
      {
  ```

```
        if ((c.cache[num_of_grow][i].tag == (addr >> tag_offset)) && (c.cache[num_of_grow][i].valid_bit == 1))
        {
            hit_increase(1); //命中了
            is_hit = true;
            p = (void *)c.cache[num_of_grow][i].block + ((addr & 0x3f) & 0x3c);
            break;
        }
    }

    if (is_hit == false) //如果未命中
    {
        bool is_full = true;
        int i = 0;
        uint8_t temp[BLOCK_SIZE];

        for (i = 0; i < c.way_num; i++)
        {
            if (c.cache[num_of_grow][i].valid_bit == 0)
            {
                is_full = false;
                break;
            }
        }
        if (is_full == true) //如果组已满
        {
            i = rand() % c.way_num;                     //取随机
            if (c.cache[num_of_grow][i].dirty_bit == 1) //脏位为1，则需保存回内存
            {
                memcpy(temp, c.cache[num_of_grow][i].block, BLOCK_SIZE);
                mem_write(c.cache[num_of_grow][i].block_num, temp);
                c.cache[num_of_grow][i].dirty_bit = 0;
            }
        }
        //更新cache
        c.cache[num_of_grow][i].valid_bit = 1;
        c.cache[num_of_grow][i].tag = addr >> tag_offset;
        c.cache[num_of_grow][i].block_num = addr >> BLOCK_WIDTH;
        mem_read(addr >> BLOCK_WIDTH, temp);                     //从内存读取数据
        memcpy(c.cache[num_of_grow][i].block, temp, BLOCK_SIZE); //写入cache
        p = (void *)c.cache[num_of_grow][i].block + ((addr & 0x3f) & 0x3c);
    }
    try_increase(1);
    return *p;
}
```

cache_write (30分)

- 思路

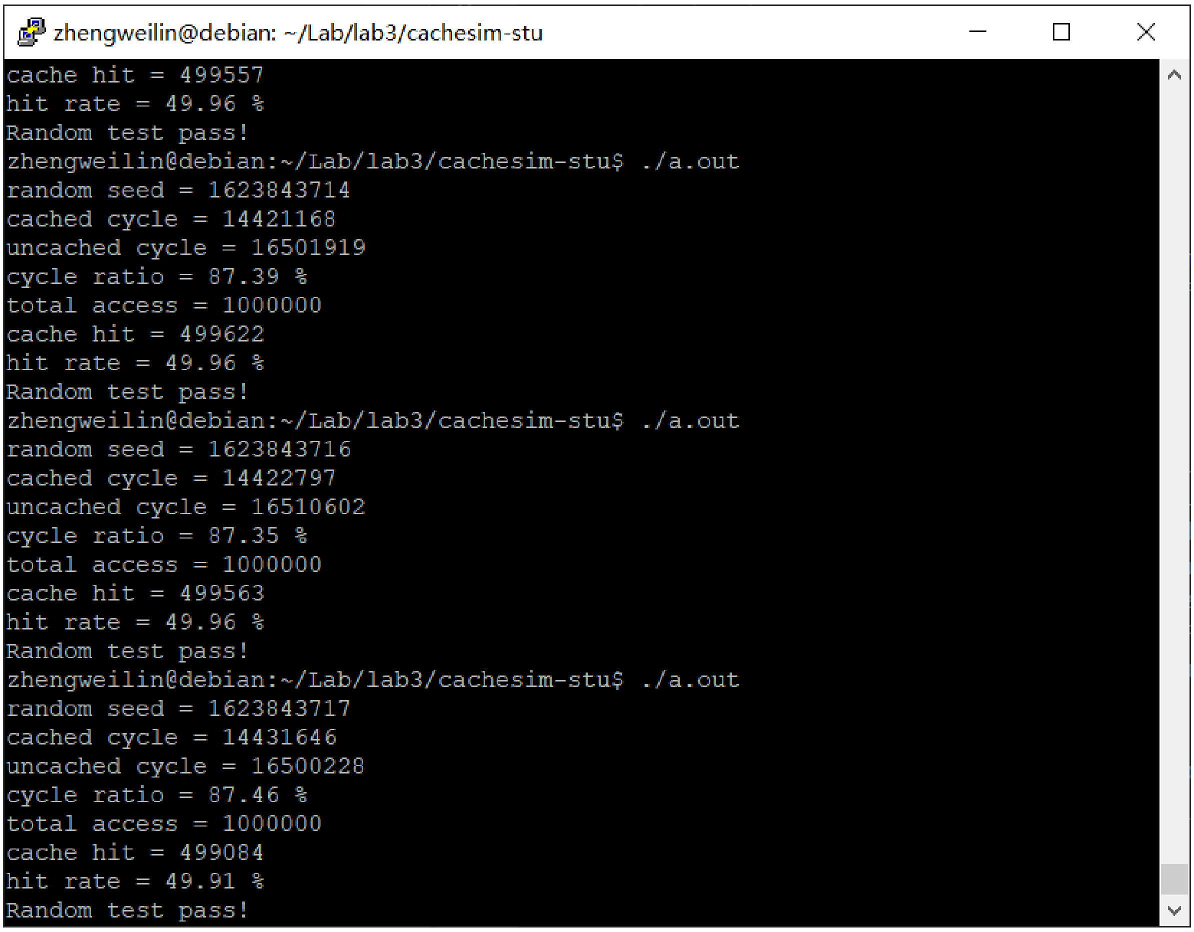
  首先取得`addr`中的组号`num_of_grow`，然后遍历`cache`中该组，查询是否命中，若命中了，直接将`data`经过掩码处理写入`cache`，并将改行脏位设1。

如果未命中，则先查询组是否已满，满了的话取组中随机一行，若脏位标记是1将其写回内存，再从内存读出数据到`cache`并将`data`经过掩码处理写入`cache`和原内存位置，更新`cache`行信息；如果未满，则直接读取数据到`cache`并将`data`经过掩码处理写入`cache`和原内存位置，并更新`cache`行信息。

- 代码

```
// 往cache中`addr`地址所属的块写入数据`data`，写掩码为`wmask`
// 例如当`wmask`为`0xff`时，只写入低8比特
// 若缺失，需要从先内存中读入数据
void cache_write(uintptr_t addr, uint32_t data, uint32_t wmask)
{

    int num_of_grow = (addr >> BLOCK_WIDTH) % c.grow_num; //取地址中的cache组号
    bool is_hit = false;
    uint32_t *p = NULL;
    int tag_offset = (BLOCK_WIDTH + (int)(log(c.grow_num) / log(2.0)));

    for (int i = 0; i < c.way_num; i++)
    {
        if ((c.cache[num_of_grow][i].tag == (addr >> tag_offset)) &&
(c.cache[num_of_grow][i].valid_bit))
        {
            hit_increase(1); //命中了
            is_hit = true;
            p = (void *)c.cache[num_of_grow][i].block + ((addr & 0x3f) &
0x3c); //写入，参照mem_uncache_write
            *p = (*p & ~wmask) | (data & wmask);
            c.cache[num_of_grow][i].dirty_bit = 1; //更新脏位，表示改过
            break;
        }
    }
    if (is_hit == false) //如果未命中
    {
        bool is_full = true;
        int i = 0;
        uint8_t temp[BLOCK_SIZE];

        for (i = 0; i < c.way_num; i++)
        {
            if (c.cache[num_of_grow][i].valid_bit == 0)
            {
                is_full = false;
                break;
            }
        }
        if (is_full) //如果组已满
        {
            i = rand() % c.way_num;                     //取随机
            if (c.cache[num_of_grow][i].dirty_bit == 1) //脏位为1，则需保存回内
存
            {
                memcpy(temp, c.cache[num_of_grow][i].block, BLOCK_SIZE);
                mem_write(c.cache[num_of_grow][i].block_num, temp);
                c.cache[num_of_grow][i].dirty_bit = 0;
            }
        }
        //更新cache
        c.cache[num_of_grow][i].valid_bit = 1;
        c.cache[num_of_grow][i].dirty_bit = 0;
        c.cache[num_of_grow][i].tag = addr >> tag_offset;
        c.cache[num_of_grow][i].block_num = addr >> BLOCK_WIDTH;
        mem_read(addr >> BLOCK_WIDTH, temp); //从内存取数据
        p = (void *)temp + ((addr & 0x3f) & 0x3c); //写入，参照mem_uncache_write
        *p = (*p & ~wmask) | (data & wmask);
        mem_write(addr >> 6, temp);

        memcpy(c.cache[num_of_grow][i].block, temp, BLOCK_SIZE);
        //c.cache[num_of_grow][i].dirty_bit = 1; //更新脏位，表示改过
    }

    try_increase(1);
}
```

最终结果截图（20分）



```
cache hit = 499557
hit rate = 49.96 %
Random test pass!
zhengweilin@debian:~/Lab/lab3/cachesim-stu$ ./a.out
random seed = 1623843714
cached cycle = 14421168
uncached cycle = 16501919
cycle ratio = 87.39 %
total access = 1000000
cache hit = 499622
hit rate = 49.96 %
Random test pass!
zhengweilin@debian:~/Lab/lab3/cachesim-stu$ ./a.out
random seed = 1623843716
cached cycle = 14422797
uncached cycle = 16510602
cycle ratio = 87.35 %
total access = 1000000
cache hit = 499563
hit rate = 49.96 %
Random test pass!
zhengweilin@debian:~/Lab/lab3/cachesim-stu$ ./a.out
random seed = 1623843717
cached cycle = 14431646
uncached cycle = 16500228
cycle ratio = 87.46 %
total access = 1000000
cache hit = 499084
hit rate = 49.91 %
Random test pass!
```

备注

助教真帅