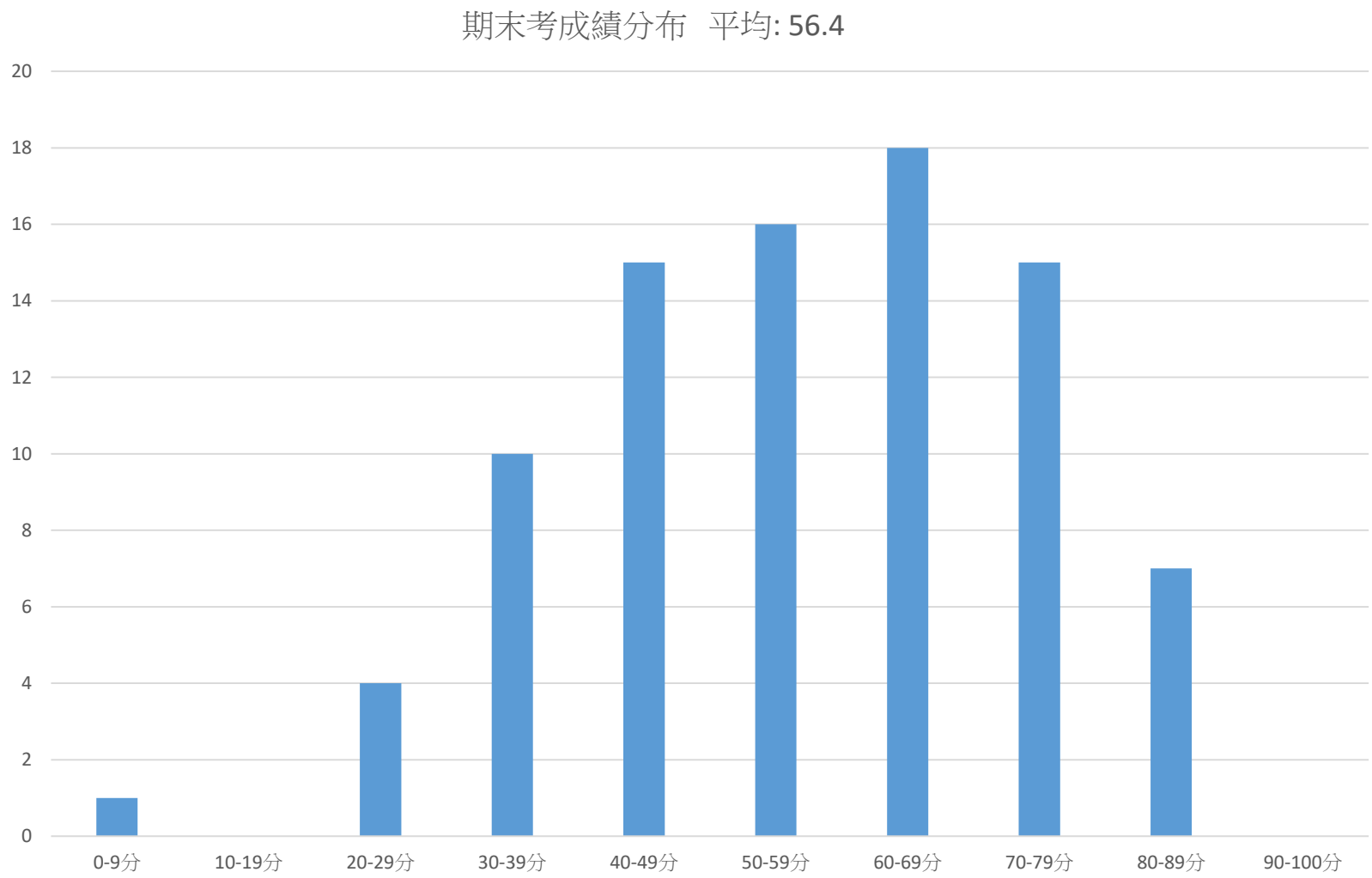

期末考成績分布　平均: 56.4
20
18
16
14
12
10
8
6
4
2
0
0-9分
10-19分
20-29分
30-39分
40-49分
50-59分
60-69分
70-79分
80-89分
90-100分

# Q1(a) [10pts]

- 根據題目的限制, 該題只有

sd x30, 0(x31)

addi x12, x12, 2

可以issue成一個packet, 且

ld x29, 8(x6)

sub x30, x7, x29

之間需一個Stall. 按照上述兩點, 其餘的instructions被issue成一個packet, 或是有其他Stall會扣1~2分

- 需要執行2個iteration, 否則扣5分
- 同樣錯誤出現在兩個iteration不會重複扣分
- 若在這題有 rearrange code, 也會根據題目限制檢查能否被 issue 成一個 packet

# Q1(a) [10pts]

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| li x12, 0 | IF | ID | EX | ME | WB | | | | | | | | | | | | | | | | | | | | |
| jal ENT | | IF | ID | EX | ME | WB | | | | | | | | | | | | | | | | | | | |
| bne x12, x13, TOP | | | IF | ID | EX | ME | WB | | | | | | | | | | | | | | | | | | |
| slli x5, x12, 3 | | | | IF | ID | EX | ME | WB | | | | | | | | | | | | | | | | | |
| add x6, x10, x5 | | | | | IF | ID | EX | ME | WB | | | | | | | | | | | | | | | | |
| ld x7, 0(x6) | | | | | | IF | ID | EX | ME | WB | | | | | | | | | | | | | | | |
| ld x29, 8(x6) | | | | | | | IF | ID | EX | ME | WB | | | | | | | | | | | | | | |
| sub x30, x7, x29 | | | | | | | | ** | IF | ID | EX | ME | WB | | | | | | | | | | | | |
| add x31, x11, x5 | | | | | | | | | | IF | ID | EX | ME | WB | | | | | | | | | | | |
| sd x30, 0(x31) | | | | | | | | | | | IF | ID | EX | ME | WB | | | | | | | | | | |
| addi x12, x12, 2 | | | | | | | | | | | IF | ID | EX | ME | WB | | | | | | | | | | |
| bne x12, x13, TOP | | | | | | | | | | | | IF | ID | EX | ME | WB | | | | | | | | | |
| slli x5, x12, 3 | | | | | | | | | | | | | IF | ID | EX | ME | WB | | | | | | | | |
| add x6, x10, x5 | | | | | | | | | | | | | | IF | ID | EX | ME | WB | | | | | | | |
| ld x7, 0(x6) | | | | | | | | | | | | | | | IF | ID | EX | ME | WB | | | | | | |
| ld x29, 8(x6) | | | | | | | | | | | | | | | | IF | ID | EX | ME | WB | | | | | |
| sub x30, x7, x29 | | | | | | | | | | | | | | | | | ** | IF | ID | EX | ME | WB | | | |
| add x31, x11, x5 | | | | | | | | | | | | | | | | | | | IF | ID | EX | ME | WB | | |
| sd x30, 0(x31) | | | | | | | | | | | | | | | | | | | | IF | ID | EX | ME | WB | |
| addi x12, x12, 2 | | | | | | | | | | | | | | | | | | | | IF | ID | EX | ME | WB | |
| bne x12, x13, TOP | | | | | | | | | | | | | | | | | | | | | IF | ID | EX | ME | WB |

# Q1(b) [10pts]

- 若有提早判斷是否要進入迴圈, 或是讓迴圈每次執行的cycle數減少(避免stall, pointer-based approach)都可以拿全部分數, 修改後的code每發現一個bug扣1分
- Possible Solution:

```
        bez x13, DONE
        li x12, 0
        jal ENT
TOP:
        ld x7, 0(x10)
        ld x29, 8(x10)
        addi x12, x12, 2
        sub x30, x7, x29
        sd x30, 0(x11)
        addi x10, x10, 16
        addi x11, x11, 16
ENT:
                bne x12,x13,TOP
DONE:
```

# Q1(c) [10pts]

- 此題需要將迴圈unroll成一次處理兩組結果, 即

```
for(i=0;i!=j;i+=4)
        b[i]=a[i]–a[i+1];
        b[i+2]=a[i+2]–a[i+3];
```

- 若沒有unroll則扣5分
- 讓迴圈每次執行的cycle數減少(避免stall, issue packet, pointer-based approach)都可以拿全部分數, 修改後的code每發現一個bug扣1分

# Q1(c) [10pts]

- Possible Solution:

```
        beqz x13, DONE
        li x12, 0
        addi x6, x10, 0
TOP:
        ld x7, 0(x6)
        add x31, x11, x5
        ld x29, 8(x6)
        addi x12, x12, 4
        ld x16, 16(x6)
        slli x5, x12, 3
        ld x15, 24(x6)
        sub x30, x7, x29
        sd x30, 0(x31)
        sub x14, x16, x15
        sd x14, 16(x31)
        add x6, x10, x5
        bne x12,x13,TOP
DONE:
```

# Q2 [10pts]

- Predict Result

| Total: 25 | Always taken | 1-bit predictor | 2-bit predictor |
|---|---|---|---|
| Branch 1: T-T-T | T-T-T | T-T-T | T-T-T |
| Branch 2: N-N-N-N | T-T-T-T | T-N-N-N | T-T-N-N |
| Branch 3: T-N-T-N-T-N | T-T-T-T-T-T | T-T-N-T-N-T | T-T-T-T-T-T |
| Branch 4: T-T-T-N-T | T-T-T-T-T | T-T-T-T-N | T-T-T-T-T |
| Branch 5: T-T-N-T-T-N-T | T-T-T-T-T-T-T | T-T-T-N-T-T-N | T-T-T-T-T-T-T |

# Q3 [10pts]

- Each cycle on a 2- Ghz machine takes 0.5 ps. Thus, a main memory access requires 100/0.5 = 200 cycles
- Direct mapped L2 AMAT: $1.5 + .07 \times (12 + 0.035 \times 200) = 2.83$
- 1.5 + 0.07*(50 + x*200) < 2.83
- x 解不合(Miss Rate < 0)
- 故該L2 cache不論多大performance都較差

- 寫出兩方的AMAT算式各3分
- x 的解答4分

# Q4 [10pts]

- 該題一共10個Entry (6個Address, 4個TLB)
每個Entry各1分
  - 4KB pages → 12bits offset

| Address | Bin | Hex | Virtual Page |
|---|---|---|---|
| 4522 | 1000110101010 | 11AA | 1 |
| 2044 | 0011111111100 | 07FC | 0 |
| 13225 | 11001110101001 | 33A9 | 3 |
| 29890 | 111010011000010 | 74C2 | 7 |
| 9094 | 10001110000110 | 2386 | 2 |
| 6666 | 1101000001010 | 1A0A | 1 |

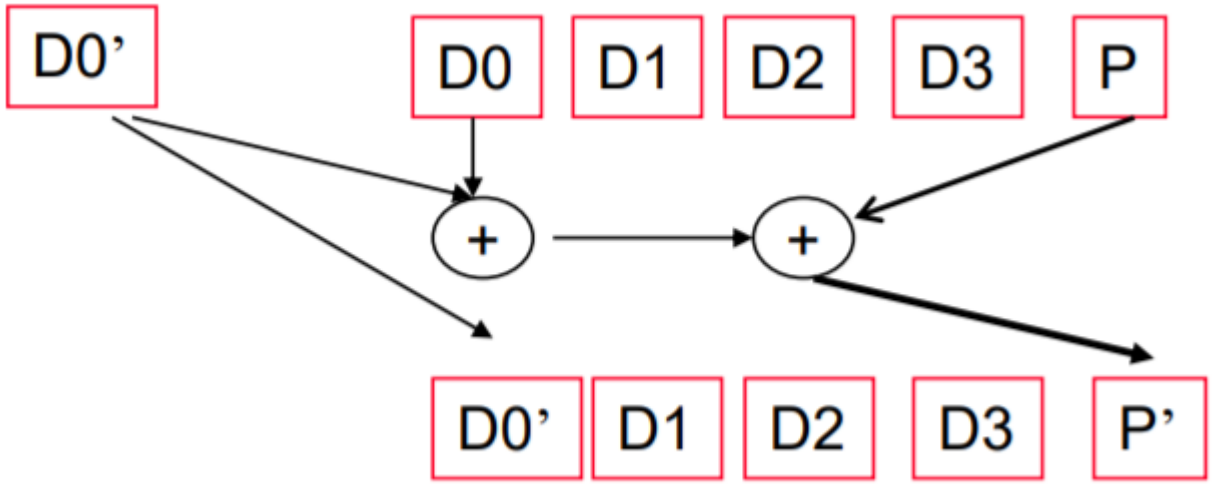
| Address | Virtual page | TLB and Page Hit/Miss | TLB | | |
|---|---|---|---|---|---|
| | | | Valid | Tag | Physical page |
| 4522 | 1 | TLB miss<br>Page Hit | 1 (last access 2) | 4 | 10 |
| | | | 1 (last access 1) | 7 | 8 |
| | | | 1 (last access 0) | 3 | 7 |
| | | | 1 (last access 3) | 1 | 11 |
| Address | Virtual page | TLB and Page Hit/Miss | TLB | | |
| | | | Valid | Tag | Physical page |
| 2044 | 0 | TLB miss<br>Page Miss | 1 (last access 2) | 4 | 10 |
| | | | 1 (last access 1) | 7 | 8 |
| | | | 1 (last access 4) | 0 | 14 |
| | | | 1 (last access 3) | 1 | 11 |
| Address | Virtual page | TLB and Page Hit/Miss | TLB | | |
| | | | Valid | Tag | Physical page |
| 13225 | 3 | TLB miss<br>Page Hit | 1 (last access 2) | 4 | 10 |
| | | | 1 (last access 5) | 3 | 7 |
| | | | 1 (last access 4) | 0 | 14 |
| | | | 1 (last access 3) | 1 | 11 |
| Address | Virtual page | TLB and Page Hit/Miss | TLB | | |
| | | | Valid | Tag | Physical page |
| 29890 | 7 | TLB miss<br>Page Hit | 1 (last access 6) | 7 | 8 |
| | | | 1 (last access 5) | 3 | 7 |
| | | | 1 (last access 4) | 0 | 14 |
| | | | 1 (last access 3) | 1 | 11 |
| Address | Virtual page | TLB and Page Hit/Miss | TLB | | |
| | | | Valid | Tag | Physical page |
| 9094 | 2 | TLB miss<br>Page Hit | 1 (last access 6) | 7 | 8 |
| | | | 1 (last access 5) | 3 | 7 |
| | | | 1 (last access 4) | 0 | 14 |
| | | | 1 (last access 7) | 2 | 3 |
| Address | Virtual page | TLB and Page Hit/Miss | TLB | | |
| | | | Valid | Tag | Physical page |
| 6666 | 1 | TLB miss<br>Page Hit | 1 (last access 6) | 7 | 8 |
| | | | 1 (last access 5) | 3 | 7 |
| | | | 1 (last access 8) | 1 | 11 |
| | | | 1 (last access 7) | 2 | 3 |

# Q5(a) [5pts]

- System A: 20 TB
- System B: 12.5 TB

# Q5(b) [5pts]

- 須System A, B都寫對才給分
- System A: The data needs to be written in two locations
  - 60ms
- System B: The system calculates parity and writes that parity, in summary this disk actions that must be done:
  **1.** Read the old data
  **2.** Read the old parity
  **3.** Write the new data
  **4.** Write the new parity
  - 120ms



# Q6(a) [5pts]

- 超過3個cycle則沒分
- Possible Solution:

| | Core 1 | | Core 2 | |
|---|---|---|---|---|
| | FU1 | FU2 | FU1 | FU2 |
| Cycle 1 | A1 | | B2 | B4 |
| Cycle 2 | A3 | A2 | B1 | B3 |
| Cycle 3 | | A4 | | |

# Q6(b) [5pts]

- 超過7個cycle則沒分
- 題目為 Fine-grained multithreaded processor, 需要Switch threads after each cycle.
- 此外須注意題目沒有說 provides out-of-order issue capabilities
- Possible Solution:

| | FU1 | FU2 |
|---|---|---|
| Cycle 1 | A1 | |
| Cycle 2 | B1 | |
| Cycle 3 | A3 | A2 |
| Cycle 4 | B2 | |
| Cycle 5 | | A4 |
| Cycle 6 | | B3 |
| Cycle 7 | | B4 |

# Q6(c) [5pts]

- 超過6個cycle則沒分
- 須注意題目沒有說 provides out-of-order issue capabilities
- Possible Solution:

| | FU1 | FU2 |
|---|---|---|
| Cycle 1 | A1 | |
| Cycle 2 | B1 | A2 |
| Cycle 3 | B2 | |
| Cycle 4 | A3 | B3 |
| Cycle 5 | | A4 |
| Cycle 6 | | B4 |

# Q7 [5pts]

- 寫出其中一點給3分, 兩點給5分, 其他答案會斟酌決定要不要給分
- 第一點若拆成兩點來寫也只有3分

## Fundamental Architectural Differences between CPU & GPU

- **Multi-core CPU**
  - Coarse-grain, heavyweight threads
  - Memory latency is resolved though large on-chip caches & out-of-order execution
- **Modern GPU**
  - Fine-grain, lightweight threads
  - Exploit thread-level parallelism for hiding latency

# Q8 [10pts]

- 須說明 Prefetching 會改變 Bandwidth ceilings 的效果,只說明該 Intensity 為 Computation Bound 只有5分