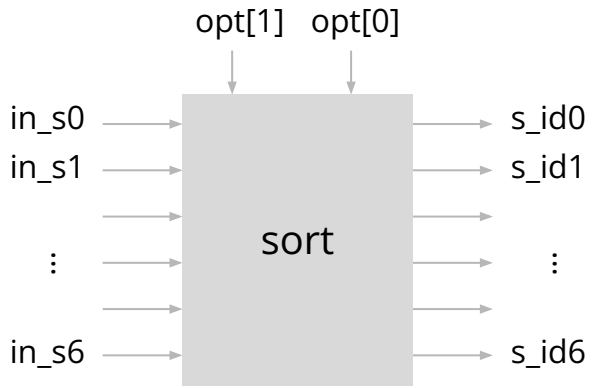
LAB 01
Exercise

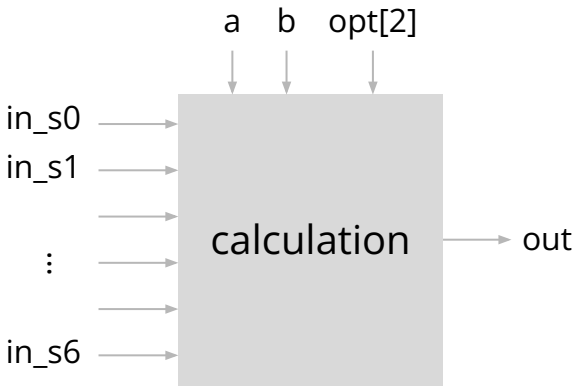
2023.03.08

Outline

- Architecture Overview
- Sort
- Signed/Unsigned
- Ascending/Descending
- Calculation

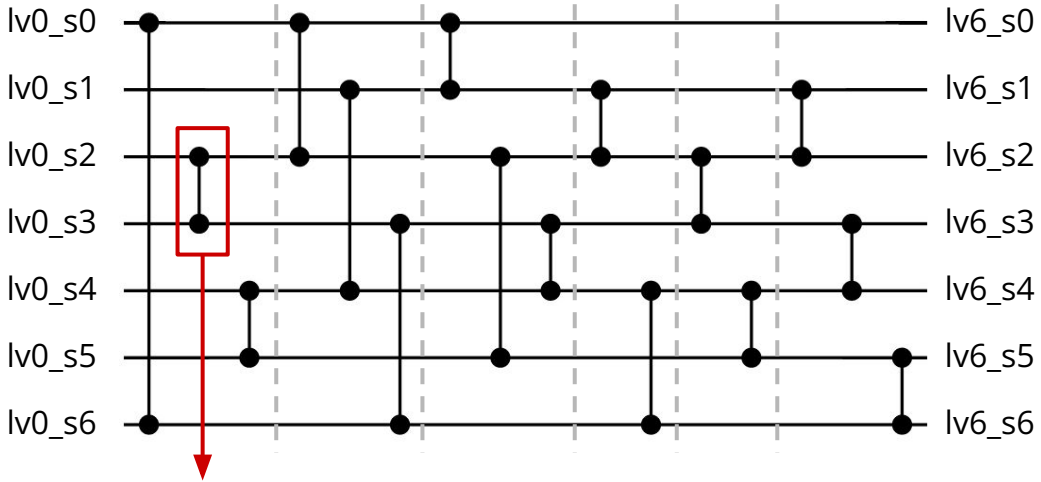
Architecture Overview





Sort

- 7elements → 16 comparators




```
assign lv1_s2 = lv0_s2 < lv0_s3 ? lv0_s2 : lv0_s3;
assign lv1_s3 = lv0_s2 < lv0_s3 ? lv0_s3 : lv0_s2;
```

Signed/Unsigned

- opt[0] = 1 : regarded as signed value
- opt[0] = 0 : regarded as unsigned value

signed		unsigned		
3	→ 011	111	→	7
2	→ 010	110	→	6
1	→ 001	101	→	5
0	→ 000	100	→	4
-1	→ 111	011	→	3
-2	→ 110	010	→	2
-3	→ 101	001	→	1
-4	→ 100	000	→	0

5-bit signed comparators

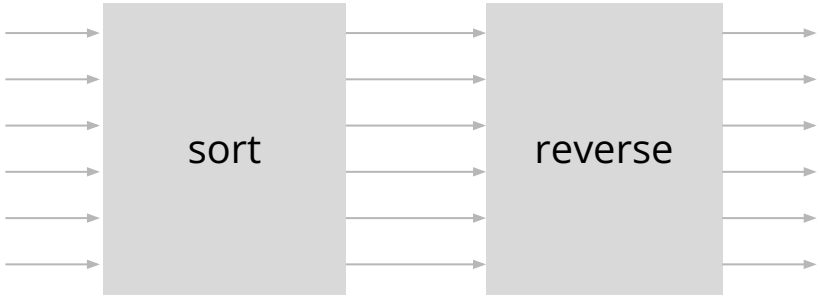
4-bit unsigned comparators

```
assign lv0_s0[6:3] = opt[0] ? {~in_lv0_s0[3], in_lv0_s0[2:0]} : in_lv0_s0;
```

Ascending/Descending

- opt[1] = 1 : descending order
- opt[1] = 0 : ascending order

original structure



complex control signals are needed to handle the same score problem

Ascending/Descending

- opt[1] = 1 : descending order
- opt[1] = 0 : ascending order

descending		ascending
7 → 111		000 → 0
6 → 110		001 → 1
5 → 101		010 → 2
4 → 100	→	011 → 3
3 → 011		100 → 4
2 → 010		101 → 5
1 → 001		110 → 6
0 → 000		111 → 7

arrange scores in descending order = arrange complement of scores in ascending order

```
assign in_lv0_s0 = opt[1] ? ~in_s0 : in_s0;
```

Merge Scores & IDs

original

```
assign bigger_score = in_s0 > in_s1;
assign bigger_id = bigger_score || (in_s0 == in_s1) && (in_id0 < in_id1);

assign out_s0 = bigger_score ? in_s0 : in_s1;
assign out_s1 = bigger_score ? in_s1 : in_s0;
assign out_id0 = bigger_id ? in_id0 : in_id1;
assign out_id1 = bigger_id ? in_id1 : in_id0;
```

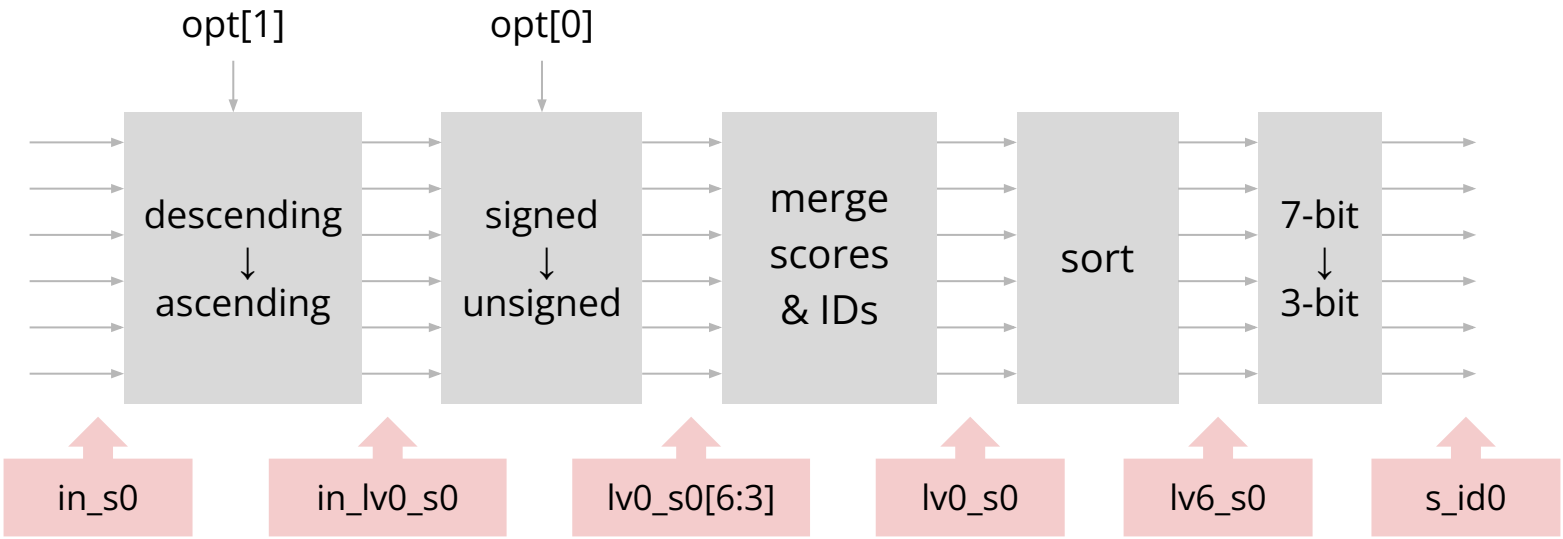
optimized

```
assign lv0_s0[2:0] = 3'd0;
assign lv0_s0[6:3] = opt[0] ? {~in_lv0_s0[3], in_lv0_s0[2:0]} : in_lv0_s0;
assign lv1_s0 = lv0_s0 < lv0_s6 ? lv0_s0 : lv0_s6;
assign lv1_s6 = lv0_s0 < lv0_s6 ? lv0_s6 : lv0_s0;
```

← ID

← Score

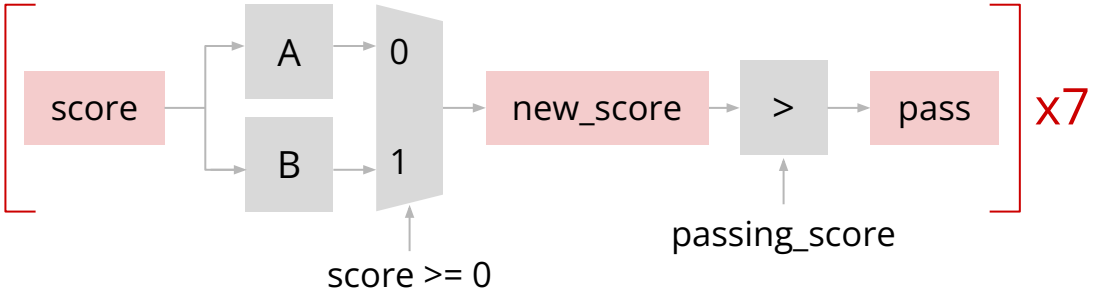
Optimized Sort



Calculation

- passing score = μ - a
- passing conditions (original)
  - A. score >= 0 → (score * (a+1) + b) > passing_score
  - B. score < 0 → (score / (a+1) + b) > passing_score

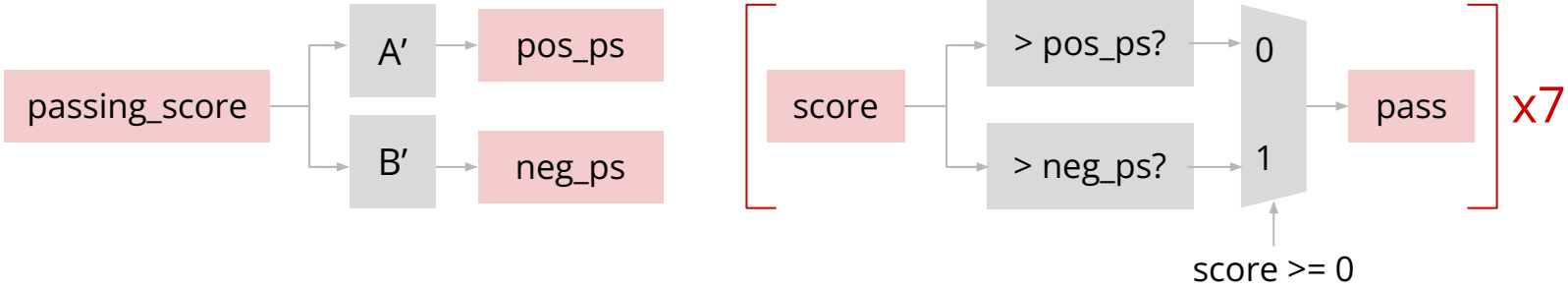
7 comparators
7 multipliers
7 dividers
14+1 adders



Calculation

- passing score = μ - a
- passing conditions (optimized)
  - A. score >= 0 → score > (passing_score - b + a) / (a+1)
  - B. score < 0 → score > (passing_score - b) * (a+1) - a

14 comparators
1 multipliers
1 dividers
4 adders



Area Report

```
Number of ports:                          60
Number of nets:                          772
Number of cells:                         699
Number of combinational cells:           698
Number of sequential cells:                0
Number of macros/black boxes:              0
Number of buf/inv:                       146
Number of references:                     37

Combinational area:              13801.233805
Buf/Inv area:                     1456.963253
Noncombinational area:               0.000000
Macro/Black Box area:                0.000000
Net Interconnect area:      undefined  (No wire load specified)

Total cell area:                 13801.233805
Total area:                 undefined
```