ICCAD-2017 Problem A: Resource-aware Patch Generation

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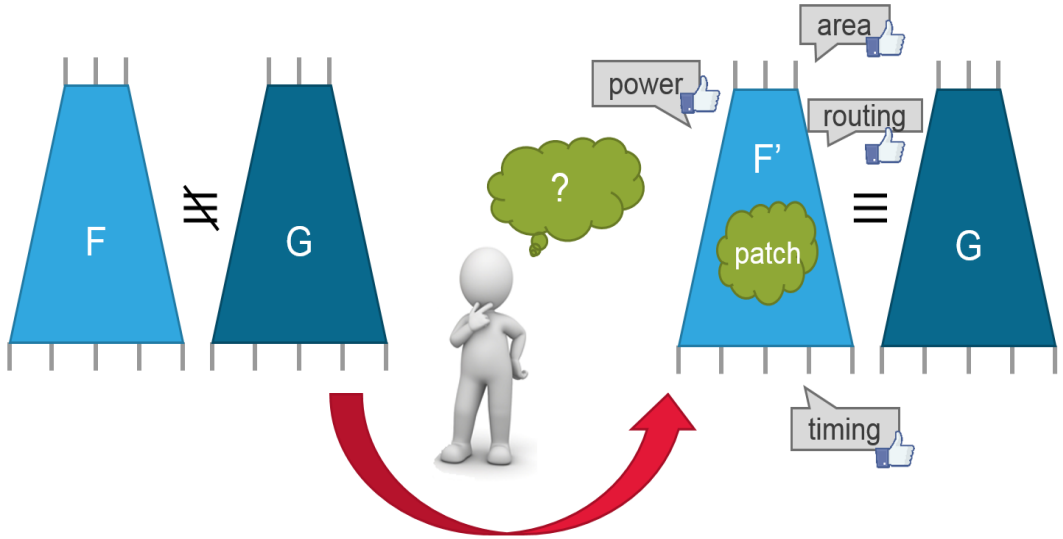
Outline

- Introduction
- Problem Description
  - Problem Formulation
  - Program Requirement
  - Evaluation Method
- Benchmark Suites
- Contest Results

Introduction

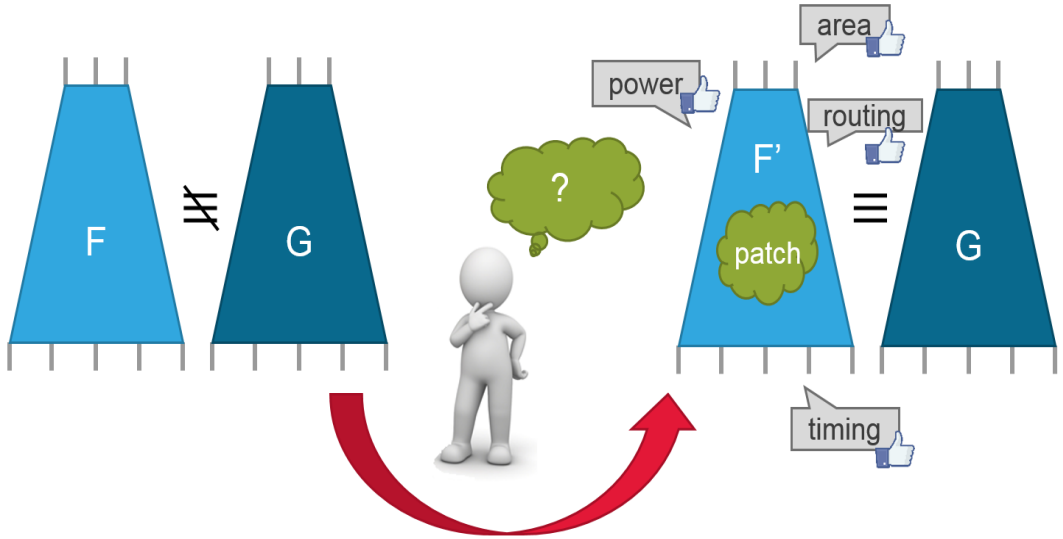
- An automated Engineering Change Order (ECO) process identifies the differences between the old circuit *F* and the new circuit *G*, and generate a corresponding *patch function* such that *F'* and *G* become equivalent
- With a functional ECO problem, the quality of patch plays an important role in the performance of the patched circuit.



The resource-aware patch generation problem

Introduction

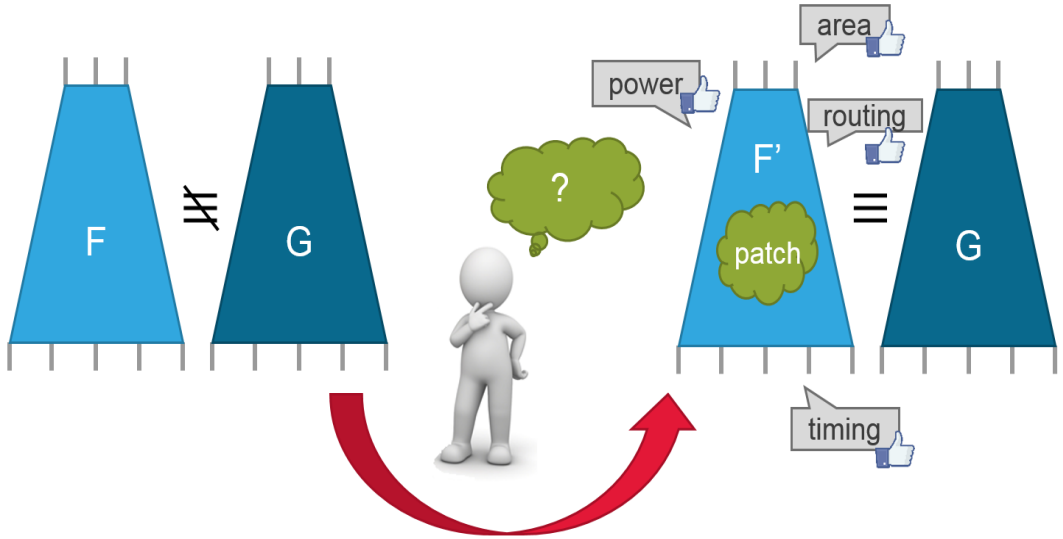
- In this contest, contestants need to generate ***patch functions*** that will make two circuits equivalent, while **minimizing the *resource cost*** of the generated patches.
- Resource cost is the comprehensive physical cost of all the patches, and minimizing the resource cost implies improving patch quality (timing, power, routing, or area).



The resource-aware patch generation problem

Introduction

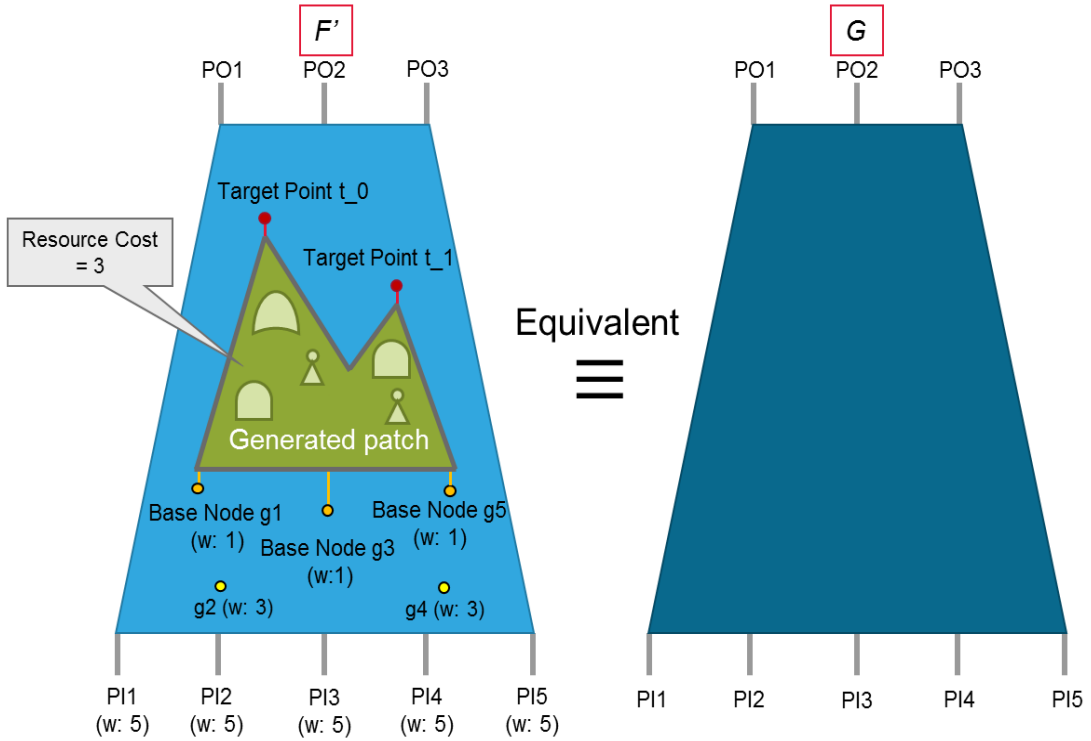
- We have assigned each internal node a reasonable ***constant weight*** to represent the corresponding physical cost if the node is used for generating patches.
- Also, the resource cost of the patches is calculated as the ***weight summation*** *of patches' support nodes.*
- This formulation can elegantly identify wanted algorithms for the resource-aware patch generation problem.



The resource-aware patch generation problem

Problem Formulation

- Given **two circuits** *F* and *G*, and the **weight information** of internal nodes in *F*, contestants need to utilize internal nodes in *F* as supports, called ***base nodes***, to generate the ***patch functions with minimum resource cost*** at a specific set of ***target points*** in *F* such that *F'*, the patched circuit, and *G* are **equivalent**. The resource cost is calculated by the **weight summation** of the used based nodes.



Example

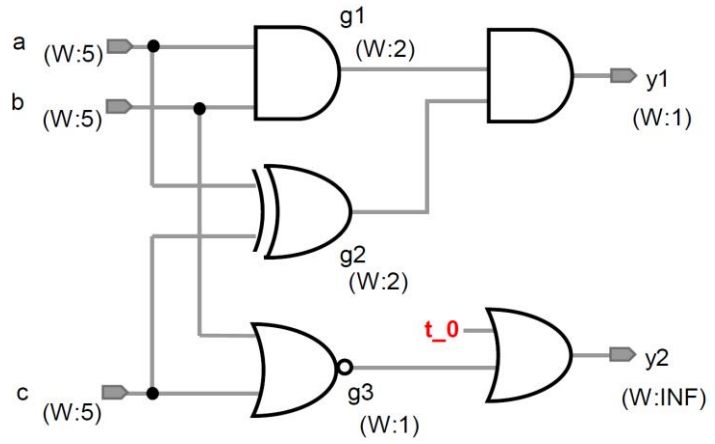
Unit 1

F.v

```
module top (y1, y2, a, b, c);
input a, b, c;
output y1, y2;
wire g1, g2, g3;
wire t_0;
and (g1, a, b);
xor (g2, a, c);
nor (g3, b, c);
and (y1, g1, g2);
or (y2, t_0, g3);
endmodule
```

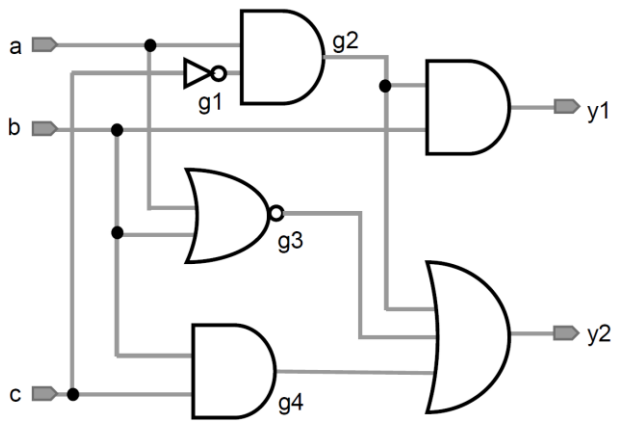
weight.txt

```
a 5
b 5
c 5
g1 2
g2 2
g3 1
y1 1
```



G.v

```
module top (y1, y2, a, b, c);
input a, b, c;
output y1, y2;
wire g1, g2, g3, g4;
not (g1, c);
and (g2, a, g1);
nor (g3, a, b);
and (g4, b, c);
and (y1, b, g2);
or (y2, g2, g3, g4);
endmodule
```



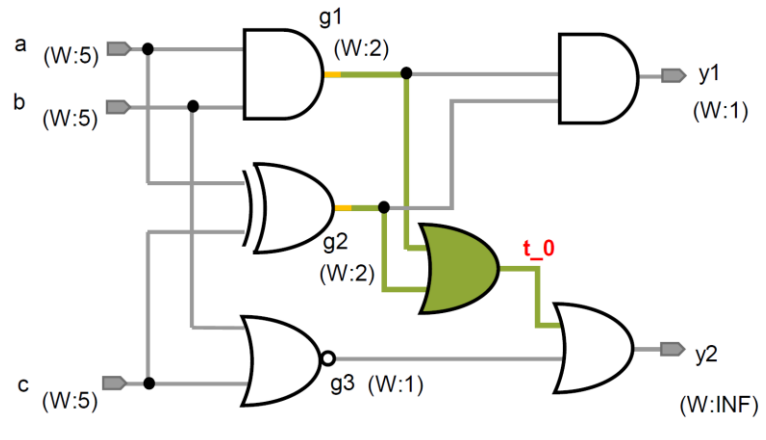
Output

patch.v

```
module patch
(y, a, b);
input a, b;
output y;
or (y, a, b);
endmodule
```

out.v

```
module top (y1, y2, a, b, c);
input a, b, c;
output y1, y2;
wire g1, g2, g3;
wire t_0;
and (g1, a, b);
xor (g2, a, c);
nor (g3, b, c);
and (y1, g1, g2);
or (y2, t_0, g3);
patch p0 (.y(t_0),.a(g1),.b(g2));
endmodule
```



Resource Cost = 2 + 2 = 4

Program Requirement

- Run on a Linux system.
- Time limit of running each testcase is 1800 seconds.
- Parallel computation with multiple threads or processes is not allowed.
- Must follow the output format.

Evaluation Method

- 1. Correctness: Must follow the output format and the patched circuit must be equivalent to <*G.v*>. Any violation gets score of 0 for that testcase.
- 2. Time limit: For each testcase, the program must output files within 1800 seconds; otherwise, the team gets score of 0 for that testcase.
- 3. Scoring according to the rank: The teams get their scores by their ranks for that testcase. The teams with the rank 1~6 will get scores of {10, 7, 5, 4, 3, 2}, respectively. The remaining teams get a score of 1. Teams are ranked based on the following criteria
  - a. We rank teams according to the resource cost. The smaller is better.
  - b. If the resource cost ties, we rank the teams by the patch size. The smaller is better.
  - c. If teams still tie, we rank them according to the runtime. The less is better.
- The team earning the **highest accumulated scores** for all the benchmarks wins the contest.

Example

Team	Resource Cost	Patch Size	Runtime	Rank	Score
A	4	1	10 sec.	1	10
B	4	4	5 sec.	2	7
C	4	4	8 sec.	3	5
D	12	3	1 sec.	4	4
E	12	3	2 sec.	5	3
F	12	4	20 sec.	6	2
G	15	1	3 sec.	7	1
H	100	20	1800 sec.	8	1
I	No Valid Output	No Valid Output	1800 sec.	N/A	0

Benchmark Suites

- In this contest, we provide benchmarks that are representatives of industrial problems with several ECO scenarios.
  - We created the benchmark suites from ISCAS, ITC99 in IWLS 2005 benchmarks, OpenCore, LGSynth'93, and some datapath parts from complex industrial designs.
  - We considered different ECO scenarios, different numbers of fix points, different fix points' distances to primary inputs/primary output, and different problem sizes.
  - Weight distribution:
    - T1: Distance-aware distribution – A.
    - T2: Distance-aware distribution – B.
    - T3: Path-aware distribution.
    - T4: Locality-aware distribution.
    - T5: The distribution composed of T1 + T3.
    - T6: The distribution composed of T2 + T3.
    - T7: The distribution composed of T1 + T4.
    - T8: Highly mixed and undulating distribution

Benchmark Suites

- A half of single-fix problems and a half of multiple-fix problems.
- 14 open cases and 6 hidden cases.
- Different types of weight distribution are also evenly distributed to the benchmarks

Information of the benchmark suite

	# of Target Points				
Distribution	1	2	4	8	12
T1	u1, u3, u7, u12			(u17)	
T2	(u15)	u5, u10			
T3	u8		u9		
T4	u4, (u18)			u11	
T5 (T1 + T3)	u13				
T6 (T2 + T3)					u14
T7 (T1 + T4)			(u19)		
T8	u2	u6, (u16)	(u20)		

*Hidden cases are in bracket symbol.

Contest Results

- Problem difficulty analysis

Alpha Test

	unit1	unit2	unit3	unit4	unit5	unit6	unit7	unit8	unit9	unit10	unit11	unit12
#Success	9/11	5/11	5/11	7/11	3/11	1/11	4/11	5/11	2/11	1/11	1/11	5/11
Avg.Time	3.92	15.17	32.4	5.52	709.2	1740	335.5	197.4	254.6	1739	1739	202.2

Beta Test

	unit1	unit2	unit3	unit4	unit5	unit6	unit7	unit8	unit9	unit10	unit11	unit12	unit13	unit14
#Success	15/15	11/15	11/15	11/15	7/15	7/15	10/15	10/15	7/15	6/15	5/15	10/15	11/15	6/15
Avg.Time	40.32	16.17	32.4	25.13	501.9	1001	378.3	256.3	91.39	891.4	994.3	141.4	6.58	373.7

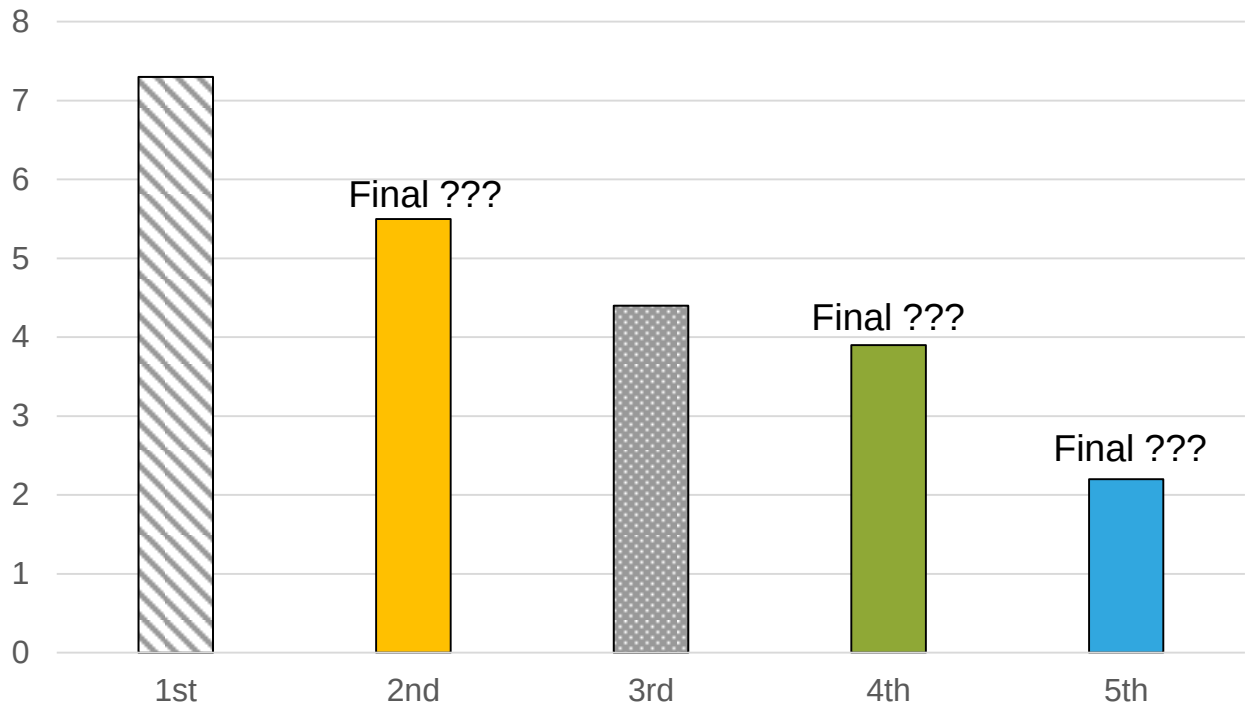
Final Test

	unit1	unit2	unit3	unit4	unit5	unit6	unit7	unit8	unit9	unit10	unit11	unit12	unit13	unit14
#Success	13/14	12/14	12/14	12/14	11/14	11/14	12/14	12/14	12/14	10/14	8/14	12/14	12/14	12/14
Avg.Time	1.36	202.2	24.47	3.4	262.6	867.5	472.0	258.5	144.1	522.5	552.1	140.5	264.3	604.4

	unit15	unit16	unit17	unit18	unit19	unit20
#Success	12/14	12/14	10/14	11/14	7/14	9/14
Avg.Time	199.0	335.3	191.3	428.6	1238	270.7

Contest Results

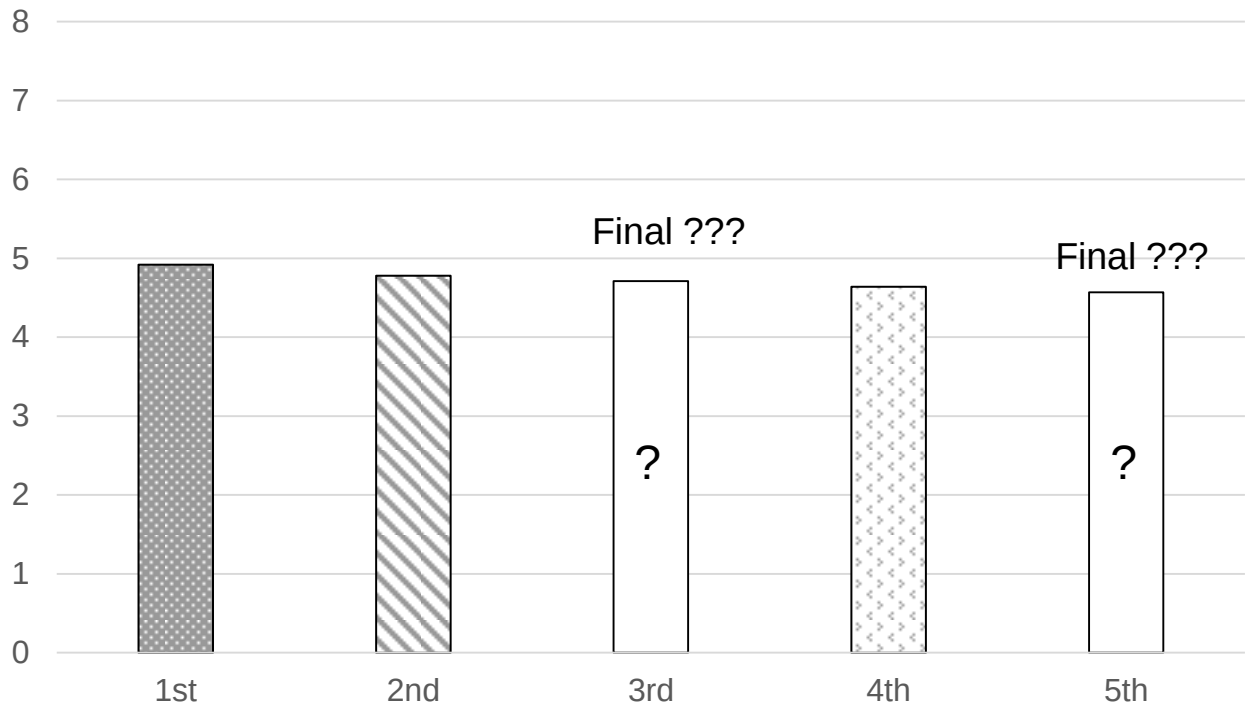
- Average score of Top 5 for Alpha Test



- Many teams have format issues

Contest Results

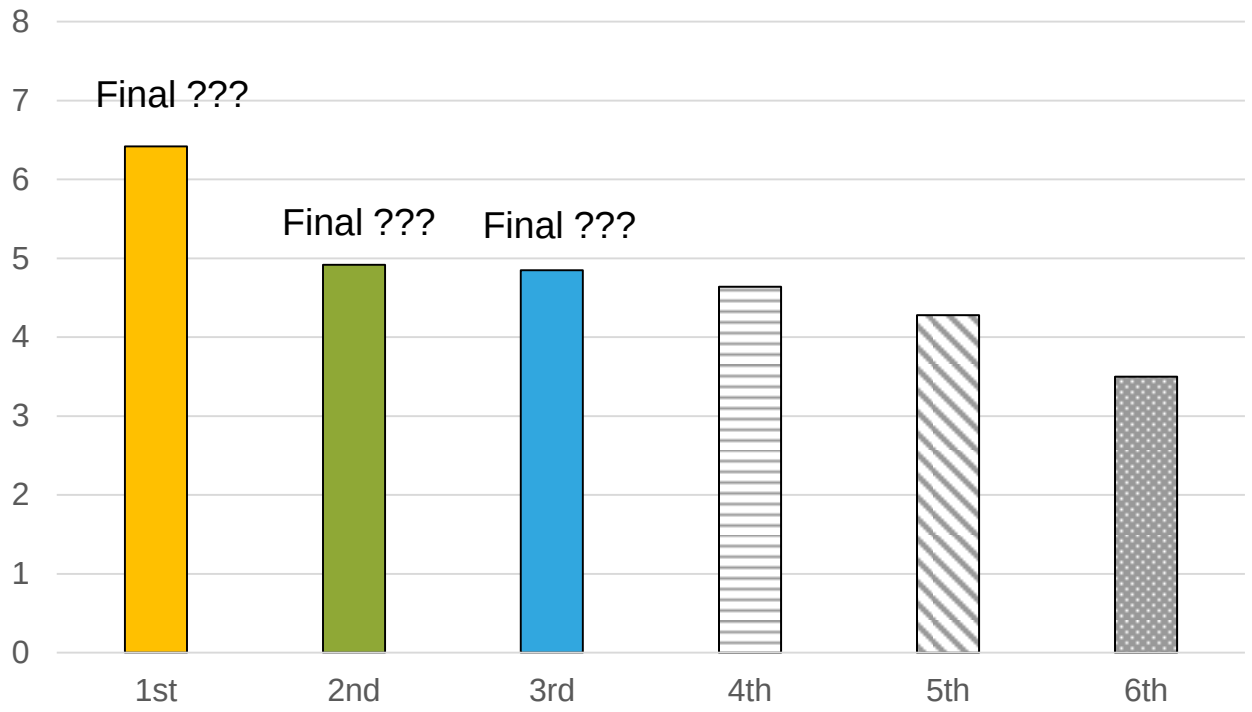
- Average score of Top 5 for Beta Test



- Still many teams have format issues

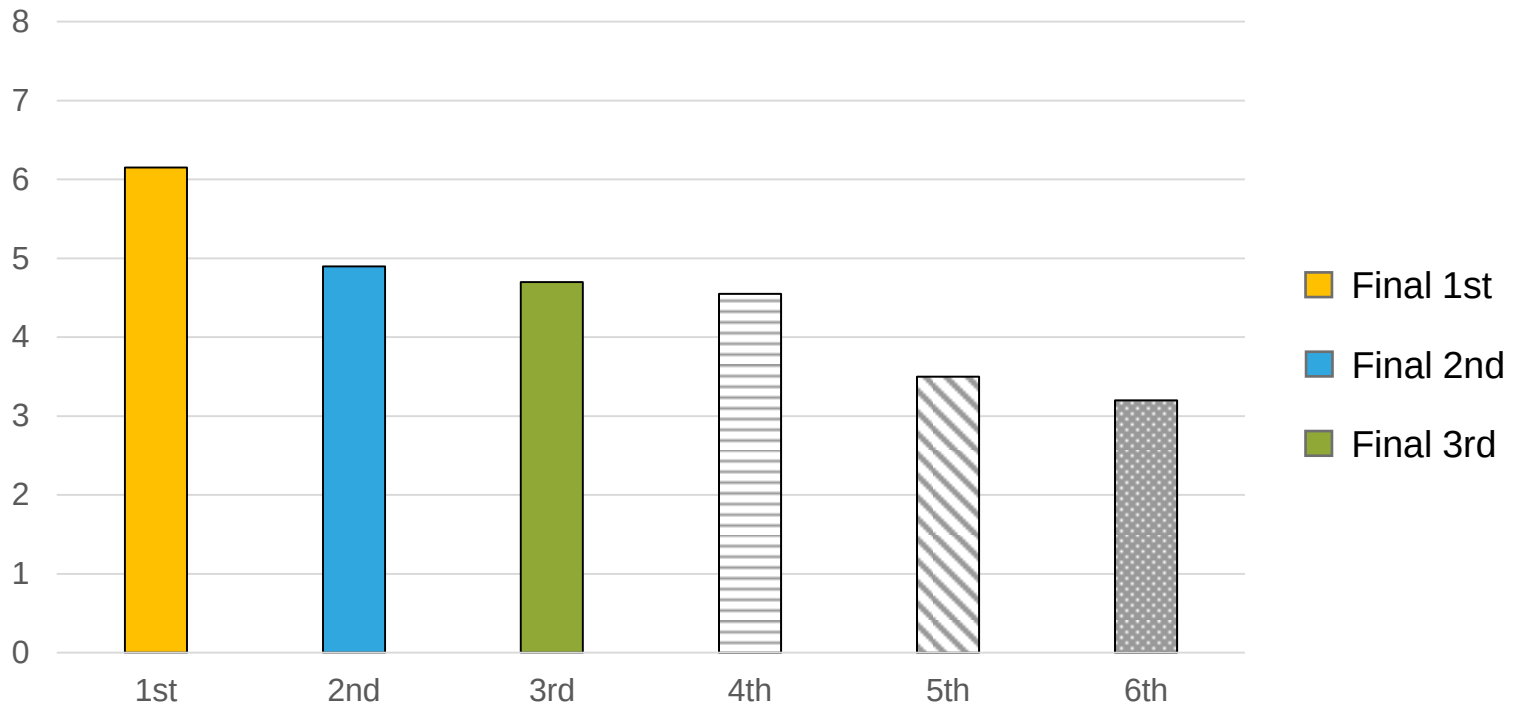
Contest Results

- Average score of Top 5 for Final Test (without hidden cases)



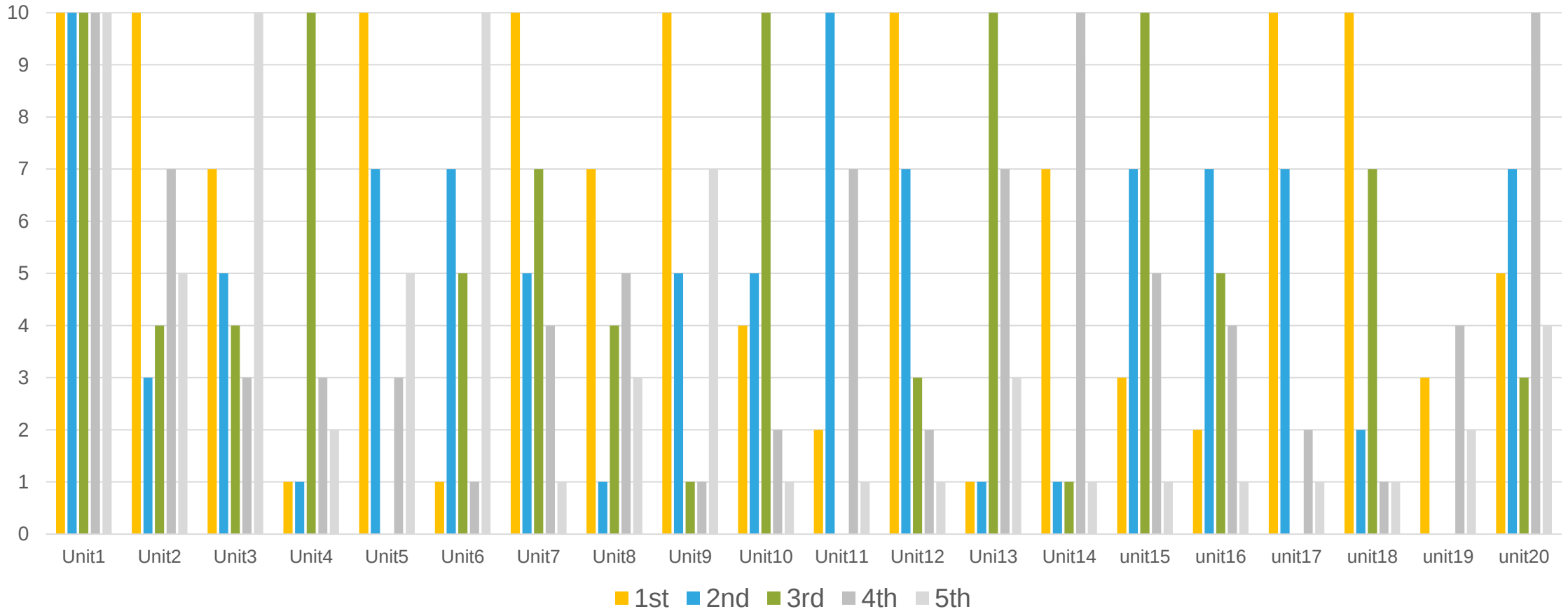
Contest Results

- Average score of Top 5 for Final Test (with hidden cases)



Contest Results

- Final Top 5 score distribution



Detailed Result

Final 1st

Testcase	Unit1	Unit2	Unit3	Unit4	Unit5	Unit6	Unit7	Unit8	Unit9	Unit10	Unit11	Unit12	unit13	unit14	unit15	unit16	unit17	unit18	unit19	unit20	Total
Elapsed Time	0.17	0.62	0.17	0.17	16.43	112.3	4.33	3.89	1.17	52.68	543.29	0.52	0.57	12.64	1.53	17.57	2.33	6.49	217.4	0.77	
Resource Cost	4	17	80	42	47	5660	284	78	50	135	4142	104	3467	95	191	318	434	18	501804	136	
Patch Size	1	4	3	5	30	6605	2	4	29	587	1063	1	9	42	11	13	79	1	7686	6	
Score	10	10	7	1	10	1	10	7	10	4	2	10	1	7	3	2	10	10	3	5	123

Final 2nd

Testcase	Unit1	Unit2	Unit3	Unit4	Unit5	Unit6	Unit7	Unit8	Unit9	Unit10	Unit11	Unit12	unit13	unit14	unit15	unit16	unit17	unit18	unit19	unit20	Total
Elapsed Time	0.17	2.08	0.32	0.22	13.5	36.29	9.73	39.29	8.18	9.84	229	1.12	6.83	74.07	3.53	5.63	20.6	58.2	N/A	16.25	
Resource Cost	4	17	80	36	47	118	284	80	50	135	760	104	3833	104	168	260	436	106	N/A	120	
Patch Size	1	5	3	2	49	5	2	5	50	310	369	1	12	65	5	13	101	21	N/A	6	
Score	10	3	5	1	7	7	5	1	5	5	10	7	1	1	7	7	7	2	0	7	98

Final 3rd

Testcase	Unit1	Unit2	Unit3	Unit4	Unit5	Unit6	Unit7	Unit8	Unit9	Unit10	Unit11	Unit12	unit13	unit14	unit15	unit16	unit17	unit18	unit19	unit20	Total
Elapsed Time	0.27	8.49	1.28	0.22	N/A	1144.2	9.3	203.16	673.03	219.19	N/A	15.52	3.28	52.12	2.29	31.29	N/A	16.14	N/A	126.18	
Resource Cost	4	17	80	32	N/A	118	284	78	86	135	N/A	104	2656	501	168	262	N/A	18	N/A	168	
Patch Size	1	4	3	1	N/A	5	2	4	55	243	N/A	1	16	49	2	11	N/A	1	N/A	11	
Score	10	4	4	10	0	5	7	4	1	10	0	3	10	1	10	5	0	7	0	3	94

Top 3 Teams

The 3rd Place

Team cada047 : *depag*

Japan

The University of Tokyo

Members: *Yusuke Kimura, Peikun Wang, Yukio Miyasaka, Kentaro Iwata, Xingming Le, Xiaoran Han*

Advisors: *Prof. Amir Masoud Gharehbaghi and Prof. Masahiro Fujita*

The 2nd Place

Team cada081: *Hilbert*

Taiwan

National Taiwan University

Member: *He-Teng Zhang*

Advisor: *Prof. Jie-Hong Roland Jiang*

The 1st Place

Team cada020 : *CCU EDA Resyn*

Taiwan

National Chung Cheng University

Member: *Ai-Quoc Dao*

Advisors: *Prof. Mark Po-Hung Lin and Dr. Alan Mishchenko*

THE END

THANKS FOR PARTICIPATION