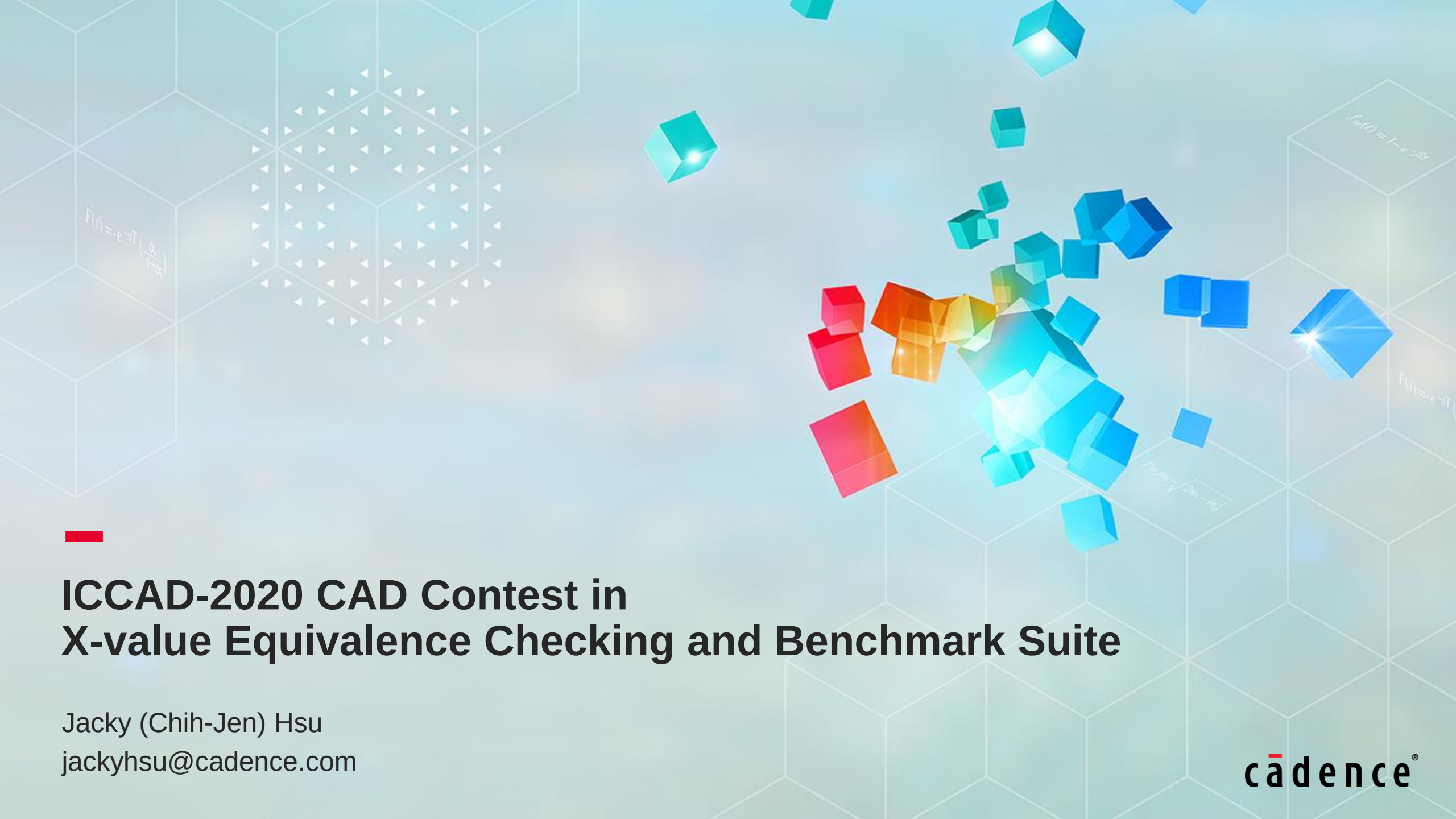
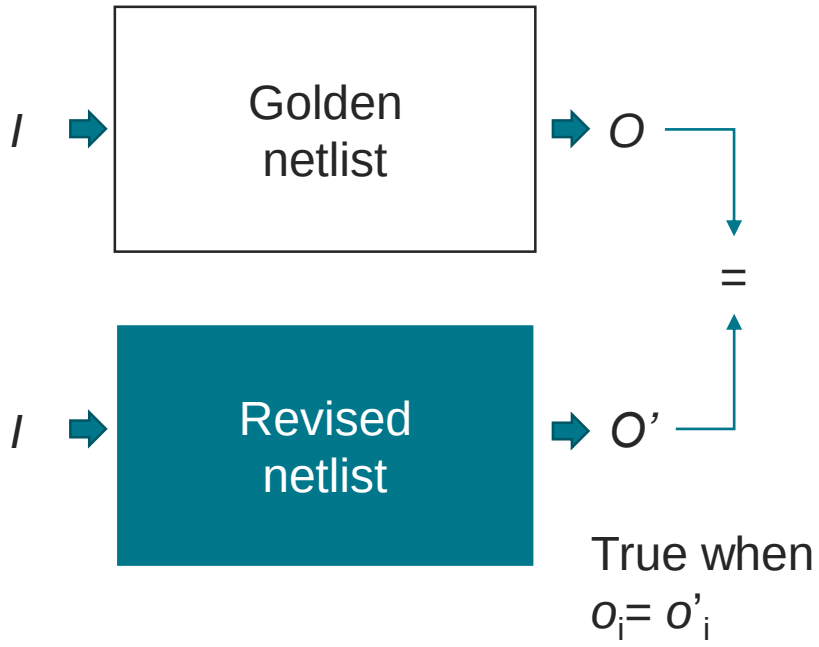


ICCAD-2020 CAD Contest in X-value Equivalence Checking and Benchmark Suite

Jacky (Chih-Jen) Hsu
jackyhsu@cadence.com

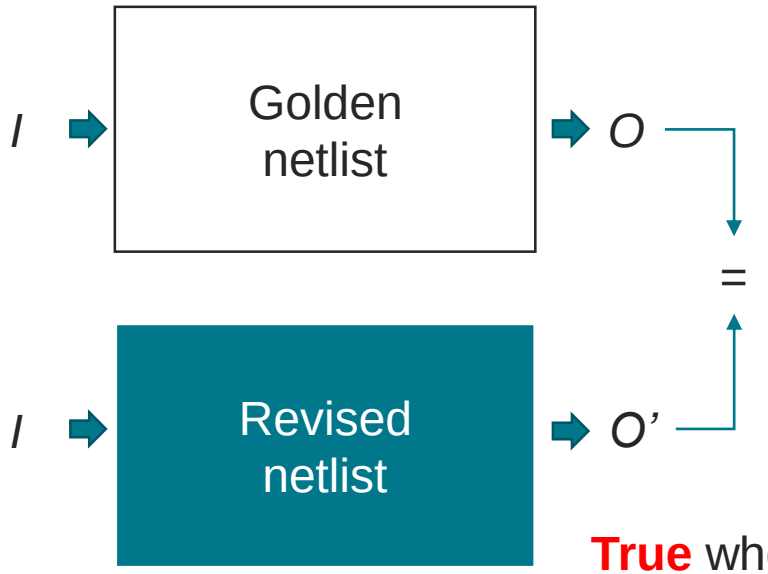
cadence

Background: Binary Equivalence Checking



- Given 2 netlists:
  - Golden and revised
  - Output equivalence or not
- Binary
- Formal methods
- Engineering techniques published [97~03]

Equivalence Checking with X-value

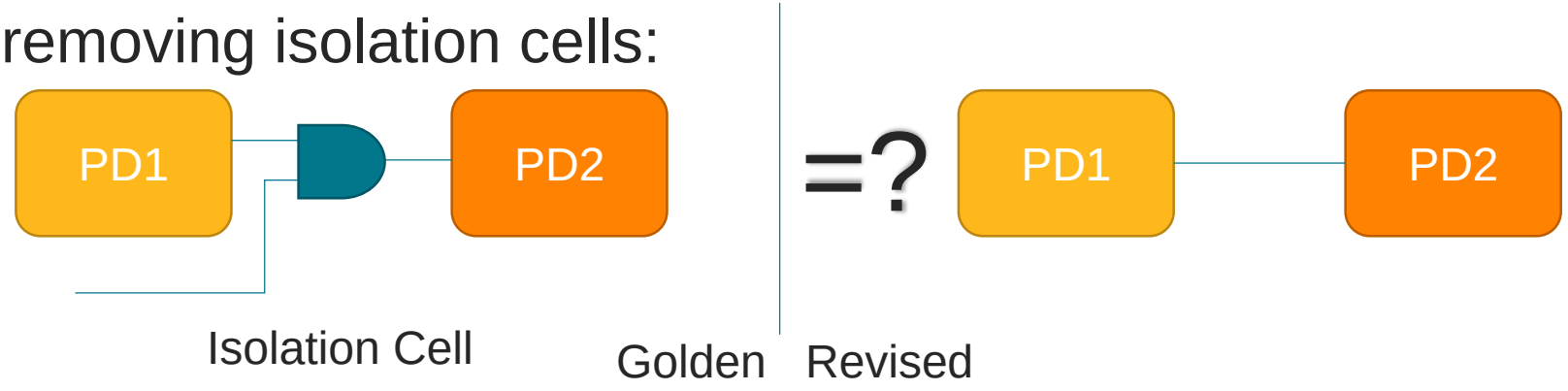


True when
$(o_i , o'_i) = (0,0), (1,1)$
$(x,0), (x,1), (x,x)$

- Netlists have 3 value, (0, 1, 1'bx)
- 1'bx honors Verilog simulation
- Check if they are *compatible*
  - (0,0), (1,1), **(x,0), (x,1)**, (x,x)
  - Asymmetry, not logically 'equivalence'
- Industrial challenges
- Good engineering technique ???

Motivation

- Low-power design has 1’bx corruption value
- Equivalence checking is 3-value compatible
- EC enables aggressive low-power optimization
  - Removing isolation cells
  - Add always on buffers
  - Optimize the circuit function related to power manager
- Example: removing isolation cells:

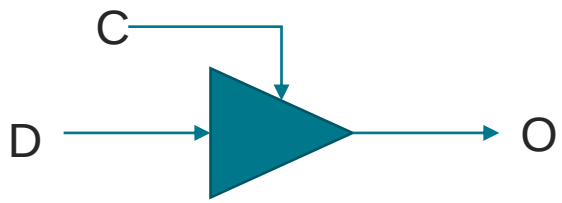


Complexity

- Internal equivalence disappears
- Cannot merge internal compatible points to simplify problem
- Much more compatible candidates than 2-value equivalence
- Formal solvers are known for 2-value heuristic
- Seek for practical solutions:
  - Encoding
  - New lemmas that can branch-n-bound the problem
  - New heuristics

Problem Formulation

- Given 2 logical netlists in 2 Verilog files with primitives and DC gate.
  - DC gates:=



D \ C	0	1	X
0	X	0	X
1	X	1	X
X	X	X	X

- Please answer if the given 2 netlists compatible equivalence
  - If they are non-equivalent, please answer a witness of input-pattern.

Evaluation Criteria

- Correct result is required
- Solved most cases win
- Compare runtime to teams solve the same number of cases
- Time limit: 30 min for each case

Benchmark Suites

- Only hidden cases are used for final evaluation
- Hidden cases are the same feature to public cases
- 18 public cases (12 EQ + 6 NEQ)
- 12 hidden cases (including 2 hard NEQ cases)

Type	Public Case	Hidden case
Index-out-of range	7	5
Case-x	3	1
1’bx	4	3
Power model	4	1

Participation Statistics

Stage	teams
Alpha	30
Beta	27
Final	28

Case solved status

Case	# solved team	#best runtime	1st place	2nd place	3rd place	4th	5th
Case20	0						
Case21	4	895	1724			982	
Case22	3	256					
Case23	18	5	56	24	77	119	5
Case24	1	124					
Case25	1	1703	1703				
Case26	10	107	107	425	173	351	115
Case27	2	948	1515		948		
Case28	14	292	296	309	292	596	372
Case29	1	4					
Case30	1	543		543			
Case31	14	296	313	357	296	611	352
#solved		11	7	5	5	5	4

Final Ranks

Rank	# Solved Cases	Total Runtime
1	7	5715.18
2	5	1657.58
3	5	1787.13
4	5	2657.95
5	4	844.9
6	4	960.23
7	4	1058.08
8	4	1179.4
9	4	1440.15
10	4	3386.02
11	3	385.44
12	3	1341.18
13	3	1966.31
14	3	2583.67
15	2	914.95
16	2	1038.33
17	2	1708.66
18	2	1892.59
19	1	36.13
20	1	877.06

Problem A
Winners

Problem A: Honorable Mention

Team cada0059

Yukio Miyasaka, Xinpei Zhang, Mingfei Yu, Qingyang Yi

Prof. Masahiro Fujita

The University of Tokyo

Problem A: Honorable Mention

Team cada0089

Hsin-Ping Yen, Sheng-Hsiu Wei, Pei-Pei Chen, Chia-Chun Lin Prof. Chun-Yao Wang, Prof. Yung-Chih Chen

National Tsing Hua University

Problem A: The 3rd Place

Team cada0071

Hsiao-Lun Liu

Prof. Chun-Yao Wang

National Tsing Hua University

Problem A: The 2nd Place

Team cada0073

Yu-Chuan Yen

Prof. Chun-Yao Wang

National Tsing Hua University

Problem A: The 1st Place

Team cada0072

Ping-Lun Wang, Yu-Neng Wang, Yun-Rong Luo

Prof. Jie-Hong Roland Jiang, Prof. Chung-Yang Ric Huang

National Taiwan University