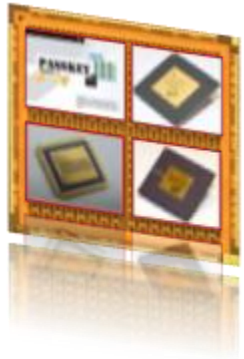


NAND-NOR :

A Compact, Fast, and Delay Balanced FPGA Logic Element

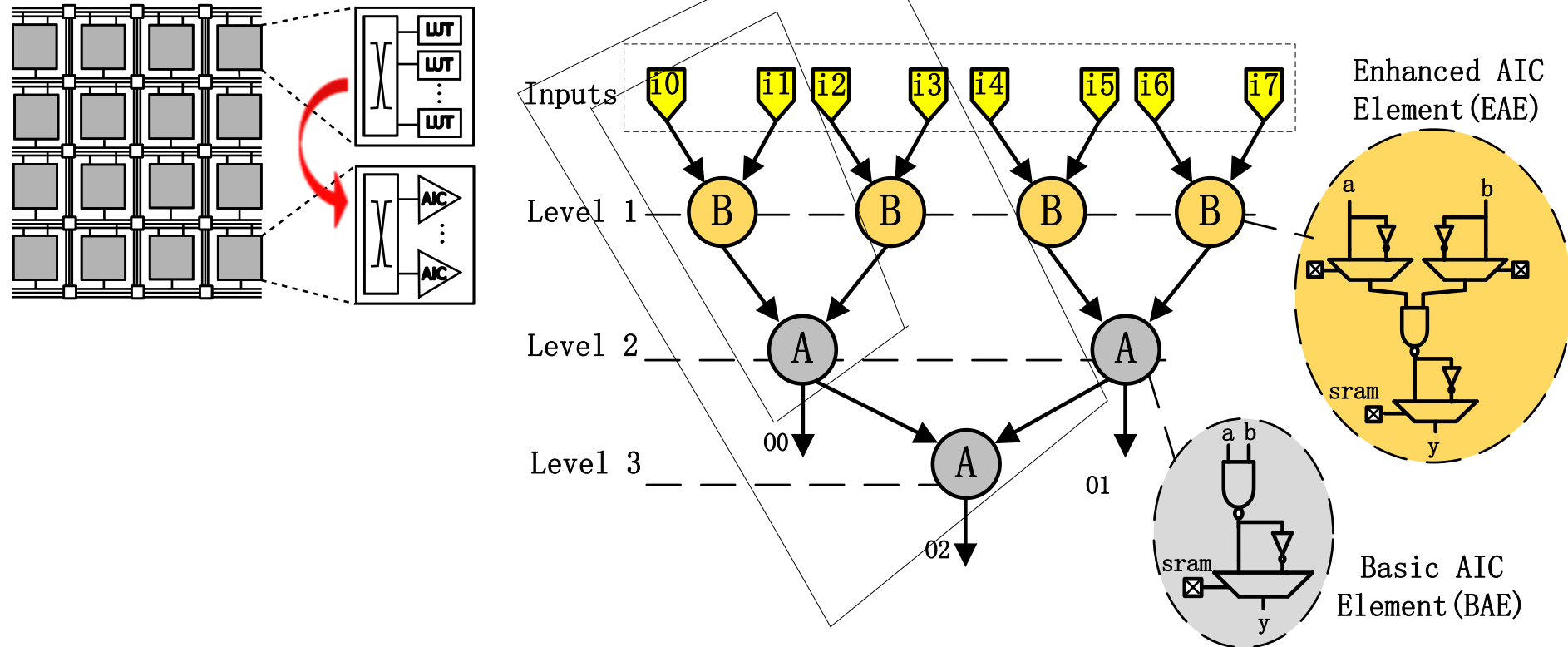
Zhihong Huang[†], Xing Wei[†], Grace Zgheib[‡], Wei Li[†], Yu Lin[†],
Zhenghong Jiang[†], Kaihui Tu[†], Paolo Ienne[‡], Haigang Yang[†]



[†] Institute of Electronics, Chinese Academy of Sciences (IECAS)

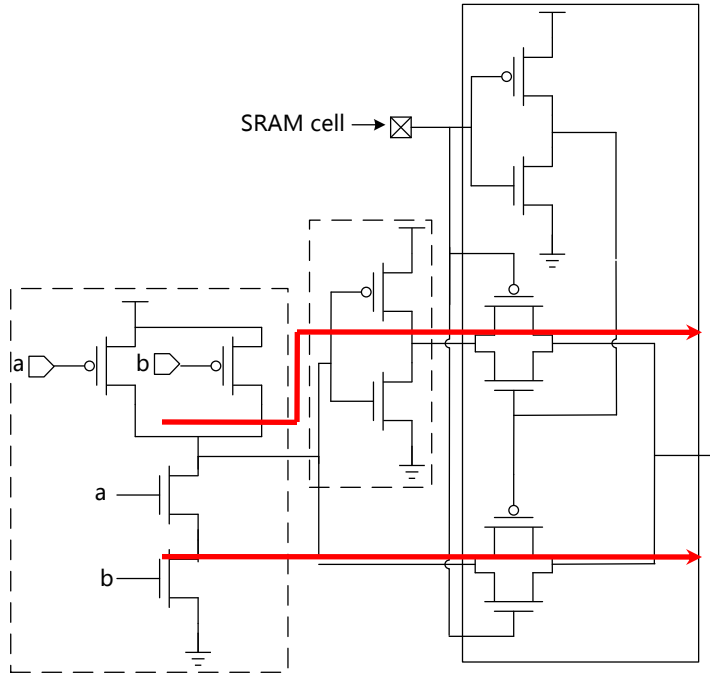
[‡] Ecole Polytechnique Fédérale de Lausanne (EPFL)

- AND-INVERTER-CONE (AIC), another possible logic element architecture compared to LUT



A 3-level AIC (AIC3) with its two types of nodes:
Enhanced AIC Element (EAE) and *Basic AIC Element* (BAE)

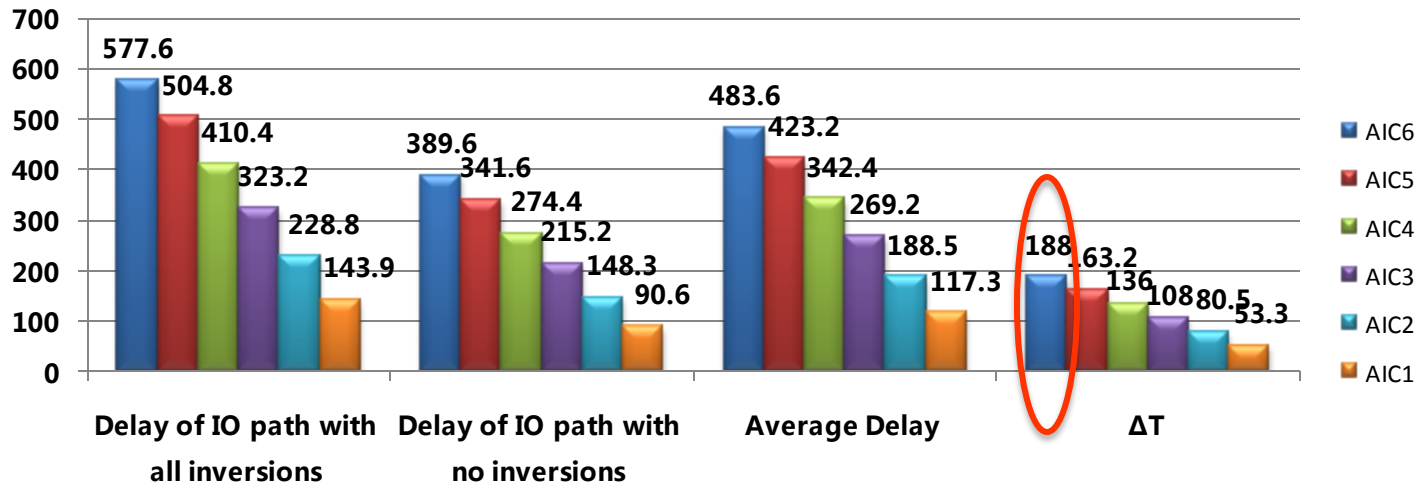
Delay discrepancy problem



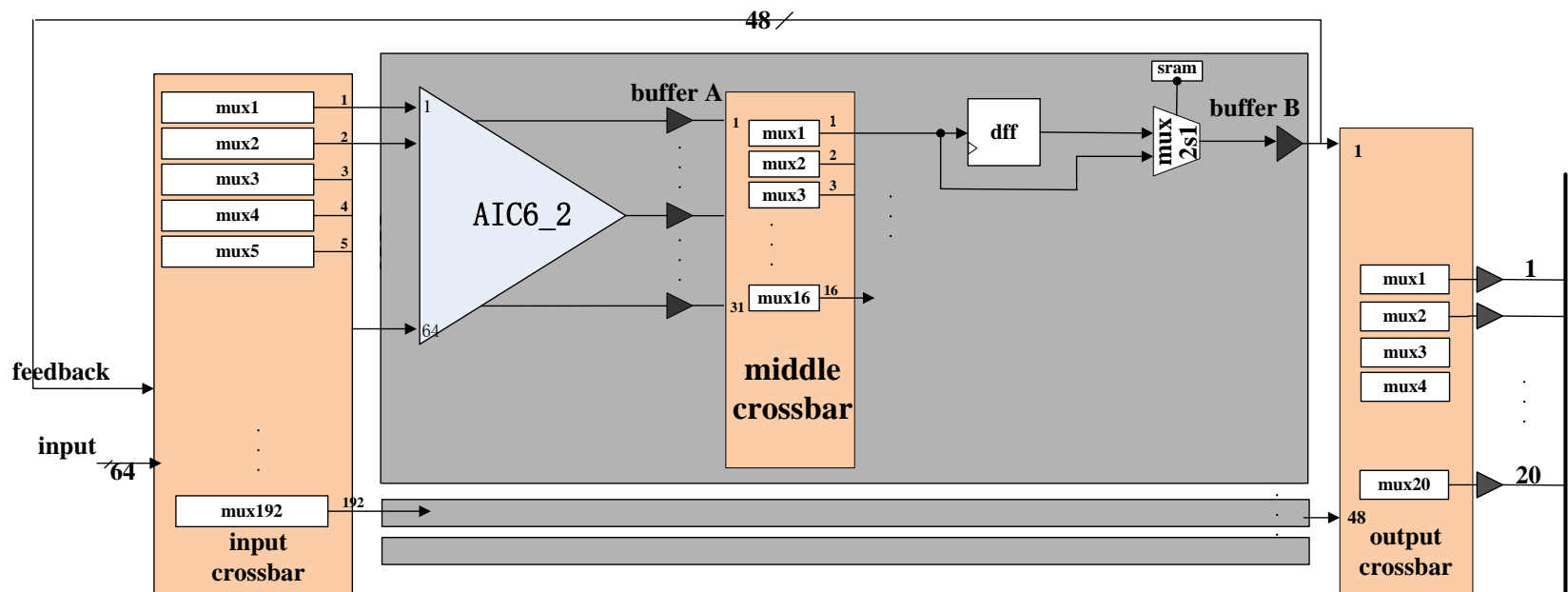
The transistor-level implementation of a BAE

- Delay increases by about 50% when all the inversions as added, as opposed to none
- Further aggravated in the case of cascaded multilevel AICs

Delay of the AIC, with up to 6 levels, for both the best and worst-case scenarios (ps).

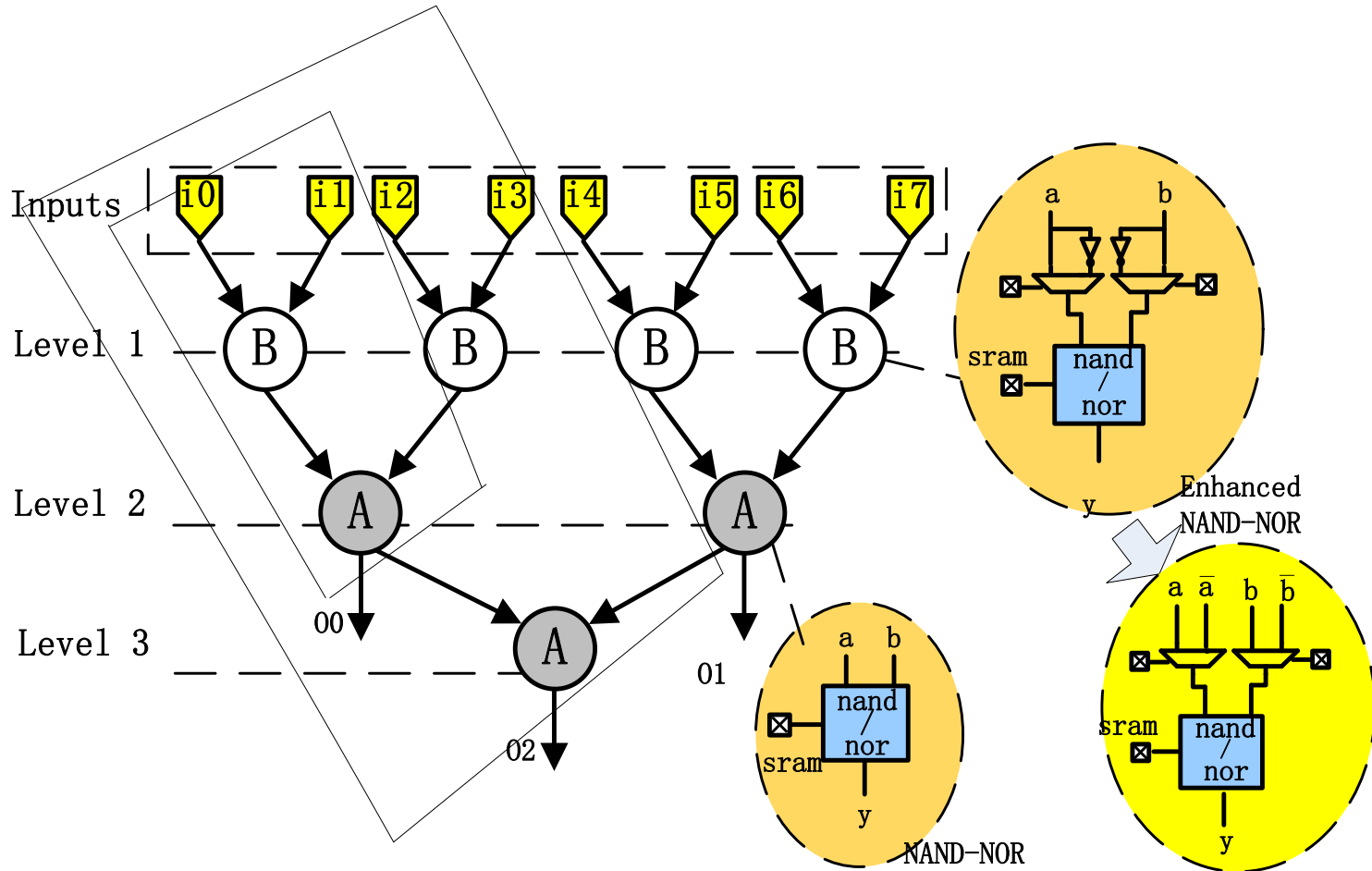


- ❑ The crossbars contribute to :
 - About **79%** of the total cluster area
 - About **43% to 70%** of the delay, depending on the selected path



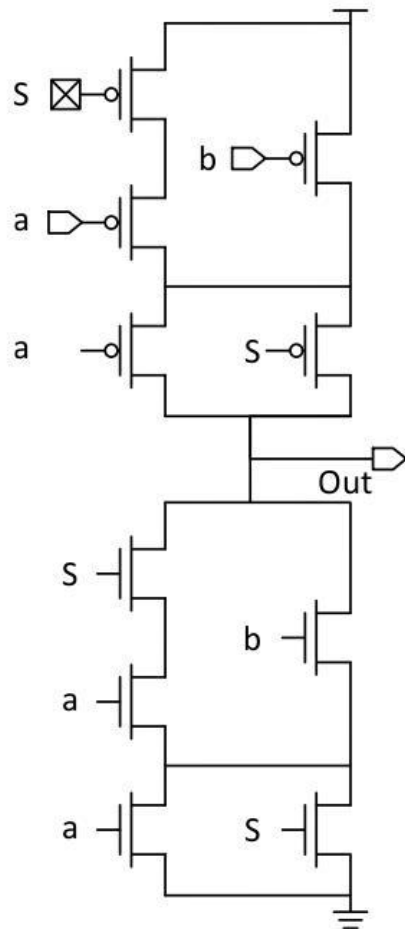
The AIC cluster architecture adopted in the latest AIC paper

NAND-NOR cone structure



A 3-level NAND-NOR with its different nodes

NAND-NOR element



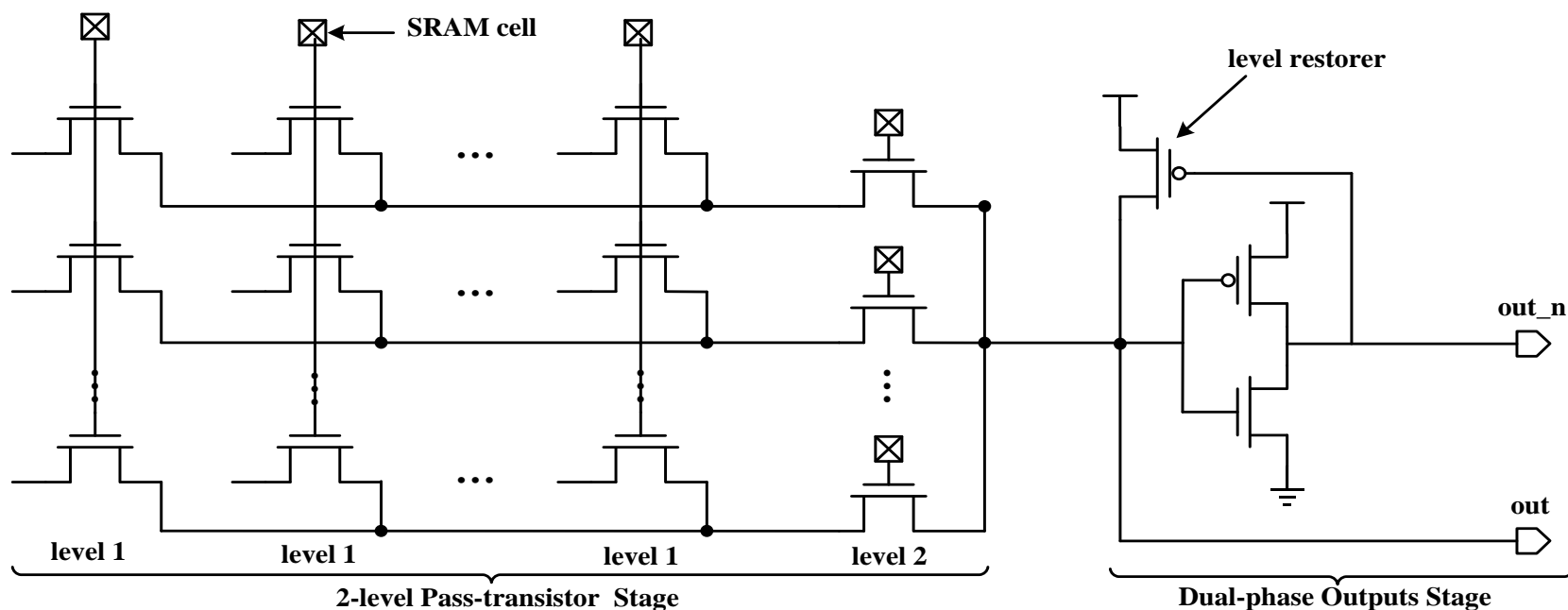
Transistor-level implementation

- ❑ The critical path traversed by the signal is reduced from 4 transistors to 2
- ❑ The total number of transistors is also reduced from 12 to 10
- ❑ Delay:
 - 14% - 46% improvement in average delay
 - 43% to 59% reduction in delay discrepancy
- ❑ Area:
 - 23% area reduction for a 6-level cone

DDM input crossbar

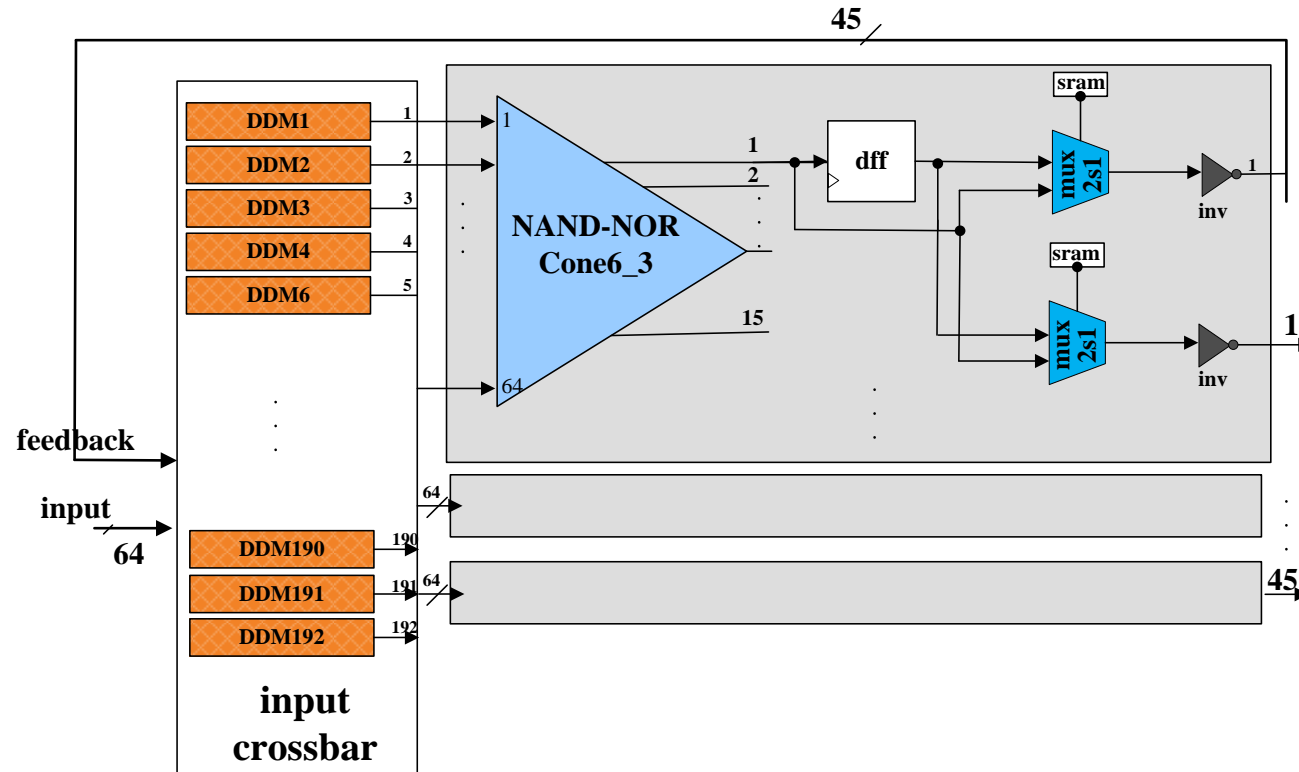


Delay-balanced Dual-phased Multiplexer (DDM)



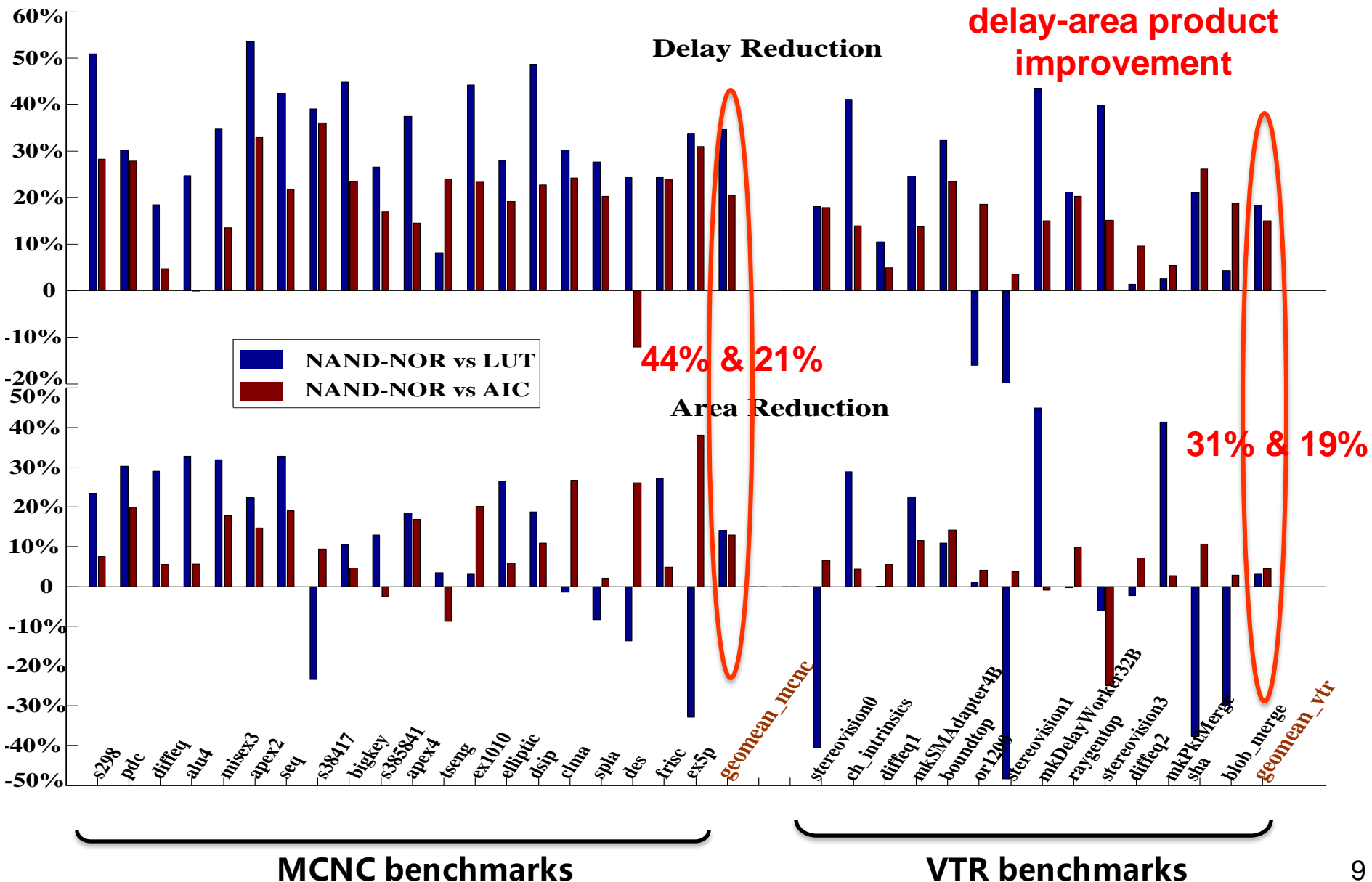
- Get both the output and its negation with relatively similar delays
- Removing the input inversions of the first level nodes: 28% area reduction for a 6-level cone
- The delay of the crossbar itself is also improved

Optimized logic cluster



- ❑ Removing the output crossbar
- ❑ Reducing the number of NAND-NOR Cone's outputs, thus removing middle crossbar
- ❑ Splitting between the feedback and direct output

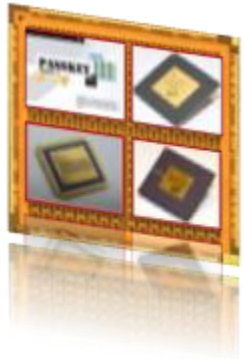
Results



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