Case Study of Diagnosing Compound Hold-time Violations

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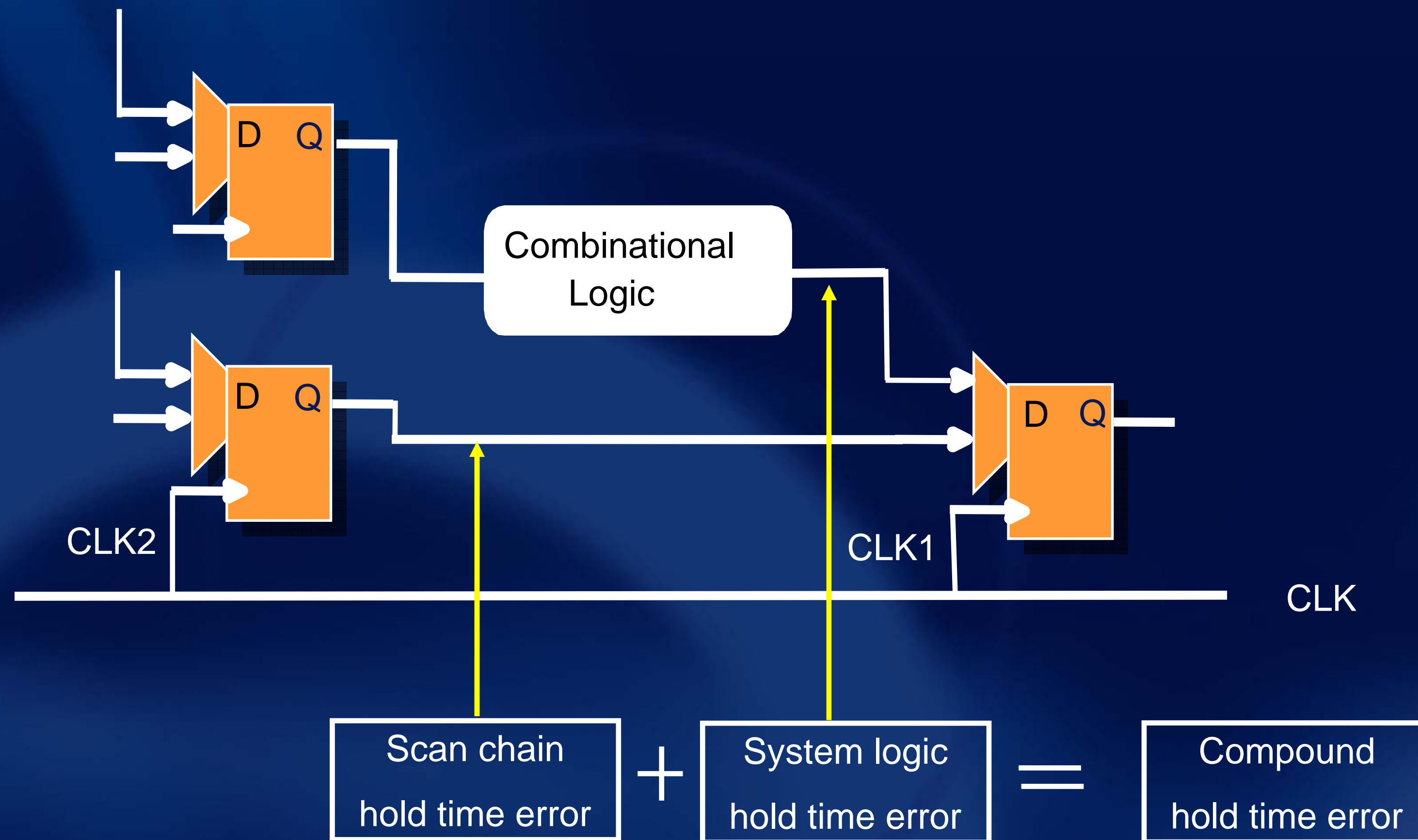
Problem Statement

- Nanometer process defects may cause silicon to fail scan test
- Design timing model variation may cause silicon to fail scan test
- Hold time violation has more possibility to occur in scan chain shift operation than in logic operation
- Advanced Scan chain diagnosis solution is useful to identify root cause of timing failures

Compound Hold-Time Error



Case Study

- 110nm process technology
- 0 yield for wafer sort
- One chain always fail
- Static Timing Analysis (STA) passed

Run diagnosis to locate the hold-time scan cell

Diagnosis

- **Collect 50 failed scan patterns from ATE**
- **Run Yieldassist™ on the first 30 patterns**

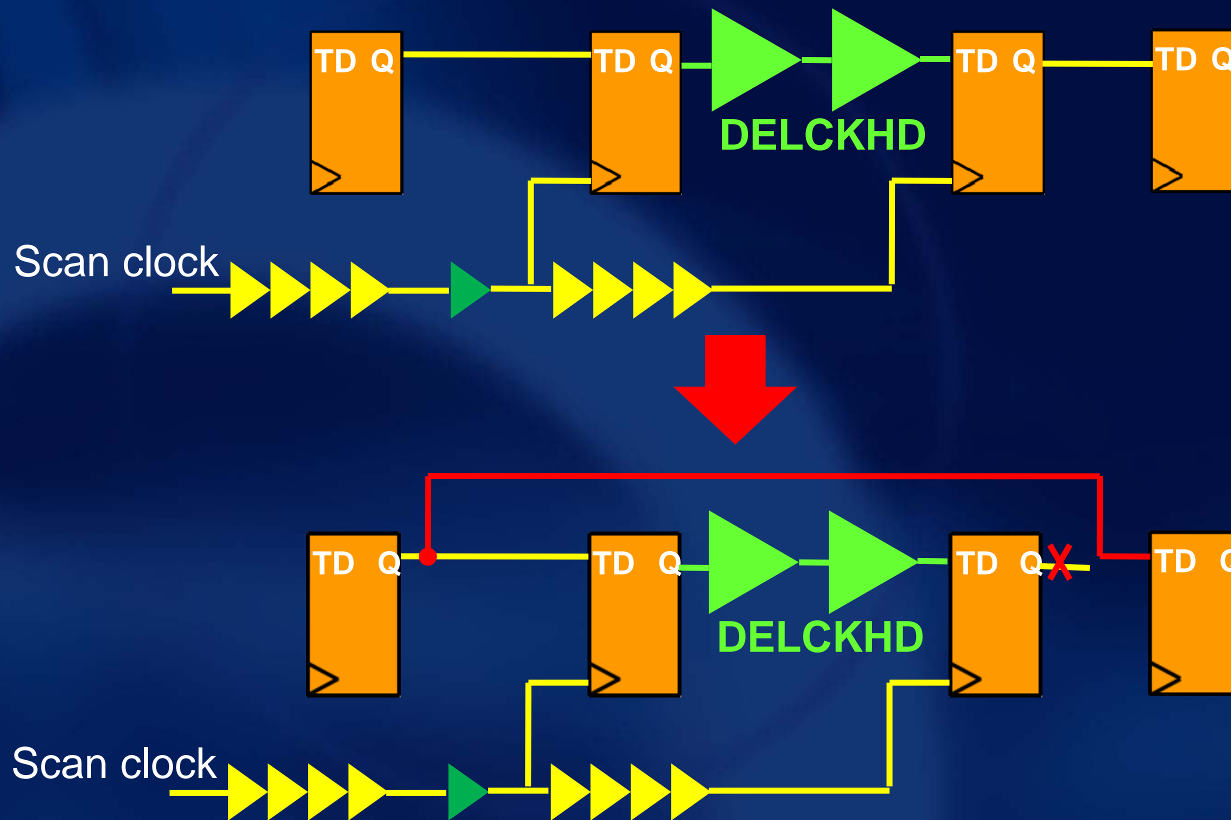
```
//  command: diagnose failures ./rpt/pat_all.cycle
... converting 31105 cycles to patterns.


#faulty_chains=1 #symptoms=1 #suspects=2 CPU_time=8.65sec

faulty_chain=1   #symptoms=1

symptom=1 #suspects=2
suspect  score type            cell_number
-------------------------------------------
1        100   FAST_TO_RISE       1642

2        100   FAST_TO_RISE       1643
-------------------------------------------
```

Diagnosis (Cont'd)

- Run Yieldassist™ on all 50 patterns
- Diagnosis resolution dropped
- Some failing bits in patterns [30-49] were caused by system logic hold-time error
- Enhance Yieldassist™ to support compound hold-time diagnosis
- Report hold-time errors are @ cells [1642, 1643]

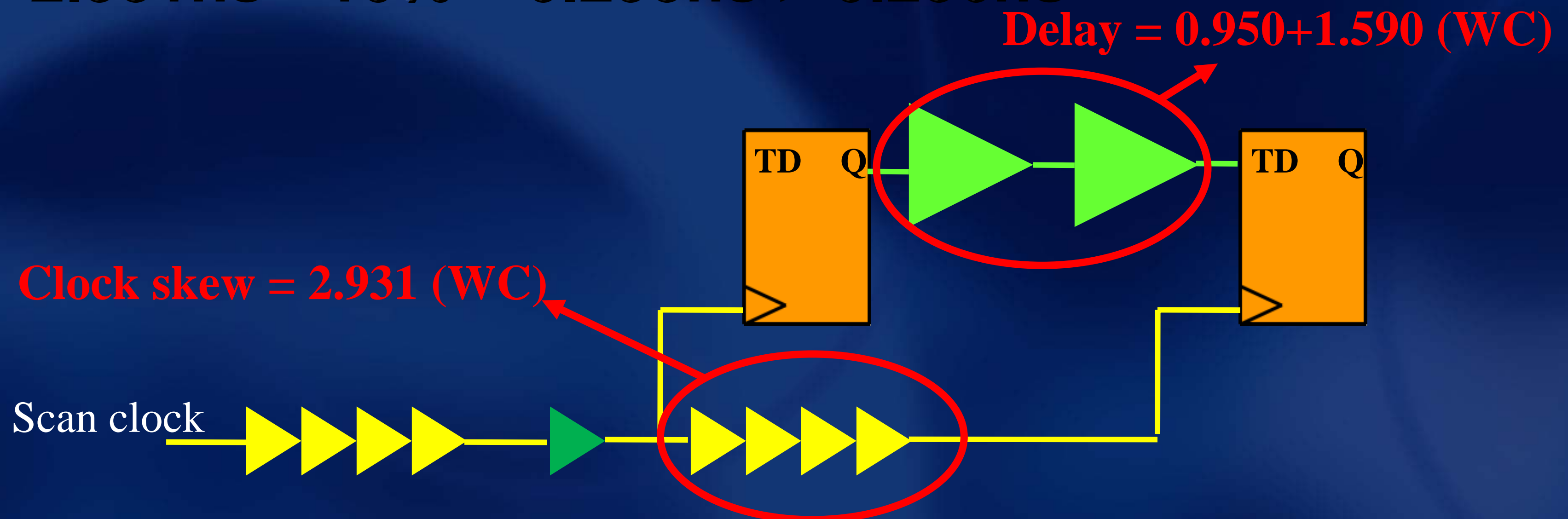
Design ECO

- **Bypass scan cells [1642, 1643]**
- **After ECO, yield > 90%**



Timing Calculation

- Hold-time slack = 0.106ns
- Timing uncertainty = 0.130ns
- Total time margin = 0.106 + 0.130 = 0.236ns
- Assume clock skew has +/- 10% variation
- 2.931ns * 10% = 0.293ns > 0.236ns



Possible Root Cause

- Due to process variation, clock skew on silicon is larger than expected by STA
- Time margin is not enough for the given large clock skew
- Large clock skew brings more timing uncertainty and worse variation tolerance capability
- Timing or model variation of delay cell is larger other standard cell

Conclusions

- Unpredictable process or model variation may invalidate STA results
- Post-silicon diagnosis is useful to locate the weak hold-time scan cells
- Using diagnosis results to guide ECO, and use ECO to validate diagnosis results
- Root cause timing failures with diagnosis and STA